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ABSTRACT

This teacher's guide was developed to aid in presenting units on general metal trades to students in Texas. The units are intended to provide students with basic knowledge and skills for each area of instruction in the general metal trades, and with the basic entry-level skills they will need to have in order to enter industry as trained workers. This guide contains five units covering the following subjects: drills and drill presses, lathe operations, milling operations, grinding operations, and shaper operations. Each unit includes most or all of these basic components of a unit of instruction: performance objectives, suggested teaching activities, information sheets, transparency masters, assignment sheets, job sheets, unit tests, and answers to unit tests. Directions to the teacher on how to use the materials, as well as references for further information are included. (KC)

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Units of Instruction

GENERAL METAL TRADES

Book II

Teacher's Guide

Prepared by Durwin Hohhertz

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USE OF THE INSTRUCTIONAL UNITS

These units cover certain instructional areas in the General Metal Trades program. Each unit includes most or all of the basic components of a unit of instruction: performance objectives, suggested teaching activities, information sheets, transparency masters, assignment sheets, job sheets, unit tests and answers to unit tests. Units are planned for more than one classroom period of instruction.

Careful study of each instructional unit will enable the teacher to determine:

A. The amount of material that can be covered in each class period

B. The skills that must be demonstrated

C. Supplies and equipment needed for skill performance

D. The amount of classroom time needed for teacher demonstration and student practice

E. Supplementary materials that must be ordered

F. Any resource personnel who must be contacted

The specific components of an instructional unit perform the following functions:

OBJECTIVES

Each unit of instruction is based on performance objectives. These objectives specify the exact behaviors the student will be exhibiting, thus providing students with a sense of direction.

Performance objectives are stated in two forms. The unit objectives state the materials to be covered in the unit of instruction and how the student will handle the material. Specific objectives state the types of performance the student will be doing to satisfy the unit objective.

A classroom discussion should follow immediately after the students read the objectives so that any questions concerning the performances expected of the student can be answered.

SUGGESTED TEACHING ACTIVITIES

Each unit of instruction has a suggested teaching activities sheet outlining steps to follow in accomplishing specific objectives.

Duties of the instructor will vary from unit to unit, but the following are minimum activities for the instructor:

1. Provide students with objectives, information, assignment, and/or job sheets

2. Discuss objectives and information sheets

3. Make transparencies

4. Demonstrate procedures outlined on job sheets (when included)

5. Give test

Many additional instructional activities and teaching methods are included to assist the instructor with classroom instruction and student motivation.

INFORMATION SHEETS

Information sheets provide content essential for meeting the cognitive requirements of the unit. These sheets provide an excellent guide for presenting required explanations necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students are encouraged to make any additional notes on the information sheets to help them in their learning process.

TRANSPARENCY MASTERS

Transparency masters provide information in a special way. Transparencies may present new information or they may reinforce information presented in the information sheets. These are particularly effective when identification is necessary.

Make the transparencies from the masters and place them in your notebook ready for immediate use.

JOB SHEETS

Job sheets are an integral part of each unit of instruction. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures specified in the job sheets give direction to the skill being taught, and allow both student and teacher to check student progress in performing the skill. Job sheets provide a ready outline to students and furnish to potential employers a picture of the types of skills being taught.

ASSIGNMENT SHEETS

Assignment sheets give direction to study and furnish activities which provide application of the material contained in the information sheet. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided for checking student progress.

ANSWERS TO ASSIGNMENTS

Assignment answers are provided for the instructor's convenience in each unit. These may be used by the teacher and/or student. Some assignments do not require specific answers, but depend upon student participation. These should be graded on an individual basis according to participation.

GENERAL METAL TRADES--BOOK II

CONTENTS

Machine Tools

- Unit I--Drills and Drill Presses
- Unit II--Lathe Operations
- Unit III--Milling Operations
- Unit IV--Grinding Operations
- Unit V--Shaper Operations

PREFACE

GENERAL METAL TRADES--BOOK III was prepared with the assistance of numerous instructors across the state in an attempt to provide adequate instructional materials for the General Metal Trades programs in Texas. Since it is known that instructional content varies from program to program, these units were developed to provide students with a basic coverage of knowledges and skills for each area of instruction in the general metal trades.

If properly presented, these materials will provide a stimulus for student interest in pursuing training in one or more areas of instruction related to the occupational areas within the General Metal Trades Cluster. Also, the information and skill training provided through the use of this guide will equip the students with the basic entry-level skills they will need to have in order to enter industry as trained workers.

This guide, along with GENERAL METAL TRADES--BOOK I, GENERAL METAL TRADES--BOOK II, and GENERAL METAL TRADES--WELDING, all produced by the Occupational Curriculum Laboratory, should serve as an excellent basis for the General Metal Trades course of study.

Bill Barnes, Ph.D.
Director
Occupational Curriculum Laboratory

ACKNOWLEDGMENTS

Appreciation is extended to the many individuals who contributed their time and talents to the development of these materials for the General Metal Trades programs.

Durwin Hohhertz, former Curriculum Writer and Director of the Occupational Curriculum Laboratory, was the principal author of this publication and thus deserves the credit for the scope and quality.

The contents of the publication were planned and reviewed by the following General Metal Trades instructors:

Richard Perez, El Paso
Ed Fahsholtz, Lubbock
Ronnie Stanley, Longview
Phillip Reed, Dallas
Ray Blohm, Dallas

A special thanks goes to Ron McBride of West Texas State University, Canyon, Texas, who assisted with the research and technical content.

Gratitude is expressed to Frances Hyatt and the clerical staff for typesetting and editing, and to Bob Norsworthy and the graphic arts staff for the many illustrations and transparency masters they provided.

John Leugemors and the Print Shop staff deserve much credit for the quality of the printing of the publication.

UNIT EVALUATION

Questions in the Unit Evaluation have been constructed to measure student achievement of each specific objective listed on the objective sheet. Individual test items may be pulled out to be used as short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz (oral or written) and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective.

ANSWERS TO EVALUATIONS

Answers are provided for each unit evaluation. These may be used by the teacher and/or student for checking student achievement of the objectives. The instructor should reinforce the correct answers when a question is missed.

PERSONALIZING AND LOCALIZING INSTRUCTIONAL UNITS

Carefully review the instructional units before using them in the classroom. In reviewing the units, you will find it necessary to localize and personalize the material based upon the needs of your students. You will also find it necessary to organize the materials in the proper teaching sequence to follow your course outline and lesson plans.

Some of the ways of supplementing units include the use of audio-visuals, attention-getters, field trips, resource personnel, games and simulations, case studies, peer teaching, role-playing, and personal experiences of both the teacher and students.

Various methods may be used in localizing a unit of instruction. You may wish to apply units of instruction to the local community, add additional materials from newspapers and magazines, invite local resource people, and arrange for field trips.

In personalizing a unit of instruction, you may want to make the course content relevant to home and/or work situations. You may wish to involve students in the planning of the unit by using their own personal experiences. Having students involved in the teaching of some of the materials is sometimes an effective example of peer teaching.

Remember that as an instructor, you may wish to add any objectives to the units of instruction based on the individual needs of the student. If this procedure is followed, you must add the corresponding information in the information sheet, add any assignment or job sheets as deemed necessary, and construct a corresponding unit test item.

UNIT I

DRILLS AND DRILL PRESSES

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to use the proper terms and safety rules in performing the various operations performed on a drill press. The student will be able to identify and use the cutting tools and accessories used on the drill press. This knowledge will be evidenced through demonstration and by satisfactorily completing the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student will be able to:

1. Match the terms associated with drills and drilling to the correct definition.
2. Name the two types of shop drill presses.
3. Identify the parts of a drill press.
4. Explain the use of cutting speeds and feeds.
5. List three purposes of cutting fluids.
6. Identify the parts of the twist drill.
7. Identify the accessories used on the drill press.
8. Point out the operations that can be performed on a drill press.
9. Identify other drilling machines used in industry.
10. Demonstrate the ability to:
    a. Sharpen a twist drill bit.
    b. Drill holes of various sizes.
    c. Ream a drilled hole.

UNIT I

DRILLS AND DRILL PRESSES

SUGGESTED TEACHING ACTIVITIES

I. Objective sheet

  A. Discuss the unit objective with the students.

  B. Discuss each specific objective with the students.

  C. Have students complete the objectives in the most logical sequence for shop organization.

  D. Add any objectives necessary.

II. Information and assignment sheets

  A. INFORMATION SHEET 1--PREPARING TO OPERATE A DRILL PRESS

    1. Discuss the uses of drill presses in the shop.

    2. Show the students examples of the types of drill presses.(Transparency 1)

    3. Demonstrate the adjustments of the drill press. (Transparency 2)

    4. Discuss the safety factors involved in operating the drill press. (Transparency 3)

    5. Use the following assignment sheets to reinforce this area of information:

      a. ASSIGNMENT SHEET 1--IDENTIFY DRILL PRESS TERMS

      b. ASSIGNMENT SHEET 2--EXPLAIN DRILL PRESS SAFETY

  B. INFORMATION SHEET 2--CUTTING SPEEDS AND CUTTING FLUIDS

    1. Explain the difference between cutting speed and feed.

    2. Explain the importance of proper speed and feed.

    3. Show students how to use the speed table or charts. (Transparency 4)

    4. Explain the speed formula. (Transparency 5)

    5. Discuss the use of cutting fluids.

6. Use the following assignment sheets to reinforce this area of information:
    a. ASSIGNMENT SHEET 3--IDENTIFY FEED AND SPEED TERMS
    b. ASSIGNMENT SHEET 4--SELECTING CUTTING SPEEDS AND FIGURING RPM

C. INFORMATION SHEET 3--TWIST DRILLS AND DRILLING ACCESSORIES

1. Explain the purpose of each part of the drill (Transparency 6)
2. Discuss the use of the different types of drills.
3. Explain sizes of drills.

    (NOTE: Provide a Drill Size Chart with each of the sizes.)

4. Demonstrate the use of various work holding devices.
5. Use the following assignment sheets to reinforce this area of information:
    a. ASSIGNMENT SHEET 5--IDENTIFY THE PARTS OF A DRILL
    b. ASSIGNMENT SHEET 6--IDENTIFY DRILLING ACCESSORIES

D. INFORMATION SHEET 4--DRILLING OPERATIONS

1. Discuss the various operations performed on the drill press. (Transparency 7)
2. Discuss the other types of drilling machines used in a production shop. (Transparency 8)

III. Transparency masters

(NOTE: Transparencies are provided in the student manuals as information sheets.)

A. TM-1--COMMON SHOP DRILL PRESSES

B. TM-2--PARTS OF A DRILL PRESS

C. TM-3--PROPER USE OF THE DRILL PRESS

D. TM-4--SPEEDS FOR FRACTION-SIZE DRILLS

E. TM-5--SUGGESTED DRILL SPEEDS

F. TM-6--PARTS OF A TWIST DRILL

G. TM-7--OPERATIONS OF THE DRILL PRESS

H. TM-8--OTHER DRILLING MACHINES

IV. Job sheets

   A. JOB SHEET 1--SHARPEN A TWIST DRILL BIT

      1. Discuss safety precautions of the grinder

      2. Provide used drill bits for student practice

      3. Demonstrate the correct drill grinding techniques

   B. JOB SHEET 2--DRILL VARIOUS SIZE HOLES

      1. Provide students with sketch or blueprint for drilling holes in materials.

      2. Demonstrate the proper layout, clamping and drilling procedures.

      3. Thoroughly cover safety precautions.

   C. JOB SHEET 3--REAM A DRILLED HOLE

      1. Provide students with sizes for drilling and reaming holes.

      2. Provide stock and sketch of hole location.

      3. Demonstrate the procedure for drilling and reaming.

V. Answers to assignment sheets

   A. Discuss the correct answers with the students.

   B. Provide additional reinforcement for areas missed on the assignment sheets.

   C. Provide appropriate other assignments.

VI. Unit test

   A. The unit test is divided into four parts

      (NOTE: Each part covers one information sheet.)

   B. Various approaches may be used in testing:

      1. Each part of the test may be given as the student reviews the information on each information sheet.

      2. Give the entire test upon completion of all the information sheets in the unit

      3. Give one or more parts of the test as an additional assignment, or to reinforce areas the student did not understand.

   C. Add test parts corresponding to any information area or sheets added to the unit.

VII. Answers to the test

A. Answers are based on total information provided in the unit.

B. For convenience of grading, add corresponding answer sheets for additional test parts.

VIII. References

A. A Suggested Basic Course Outline for General Metal Trades Cluster. Occupational Curriculum Laboratory, East Texas State University, Commerce, Texas 75428

B. Wasiloff, Thomas. Machine Shop Skill Manual. American Technical Society, Chicago, Illinois 60637

C. Walker, John R. Modern Metalworking. Goodheart-Wilcox. South Holland, Illinois 1976

UNIT I

DRILLS AND DRILL PRESSES

INFORMATION SHEET 1--PREPARING TO OPERATE A DRILL PRESS

I. Terms and definitions

- A. Drilling--forming a hole with a drill.
- B. Twist drill--a cutting tool with a spiral grooved body, used for cutting holes.
- C. Drill press--a machine used for drilling holes in material. Work is fixed on table or base of machine.
- D. Clamping devices--tools used to fasten workpiece to table.
- E. Operations--jobs performed.

II. Common shop drill presses

- A. Bench model--operated by rotating a cutting tool (drill) against the material with enough pressure to cut and penetrate the material. It is usually mounted on a bench and is smaller than floor-type drill press. Used for smaller jobs.
- B. Floor model--operates in the same principle as bench-type drill press. Used for larger jobs due to larger working area of table movement.

III. Parts of a drill press

- A. Base--supports the machine.
- B. Table--supports workpiece.
- C. Column--supports the table.
- D. Table clamp lever--locks table to column.
- E. Chuck--holds or clamps drill in place.
- F. Spindle lock clamp--locks spindle in place.
- G. Depth gauge--measures depth of holes.
- H. Switch--turns power on or off.
- I. Speed adjustment handwheel--control with dial which adjusts cutting speeds.

  CAUTION: Turn handwheel only while machine is running.
- J. Power assembly--the system of electric motor, pulleys, and belts to provide and transmit power needed to operate machine and cutting action.

IV. Common adjustments

(NOTE: Size--determined by the distance of the spindle from the column and by capacity of drill chuck.)

A. Speeds--different RPMs to set for different materials.

B. Twist drills--cutting angles change for different metals.

C. Work holding devices--positioning clamps, and drill press vises for different operations.

D. Table--a surface which can slide on column, up or down, and side to side.

E. Table angles--(some models) position changes to allow circular movement of table in degrees to drill holes at an angle.

V. Safety

A. Keep your hands away from moving parts.

B. Protect your eyes from flying chips.

C. Do not handle metal chips with your hands.

(NOTE: Use a brush to clean chips from the drill.)

D. Do not wear loose clothes, and keep long hair tied back while operating the drill press.

E. Make sure that machine is in good working order.

F. Keep drills sharp and clean.

G. Clamp your work solidly. Do not hold work with hands.

H. Never attempt to stop machine with your hands.

I. Stop machine when measuring or making adjustments.

J. Place a piece of wood over the table when removing drill bits from the drill press to prevent the bits from falling through the holes in the table.

(NOTE: Small drills will be damaged and larger drills can cause foot injuries if they fall.)

K. Treat cuts and scratches immediately.

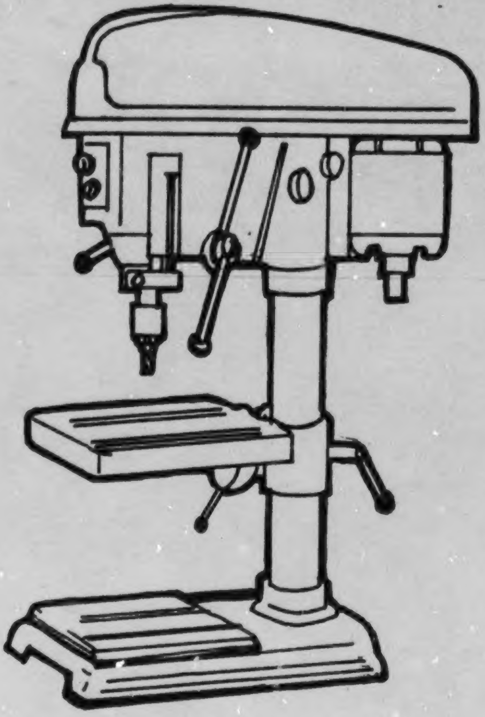
L. Always remove chuck key from the chuck before turning on the power.

M. Wipe spilled cutting oil from machine and floor.

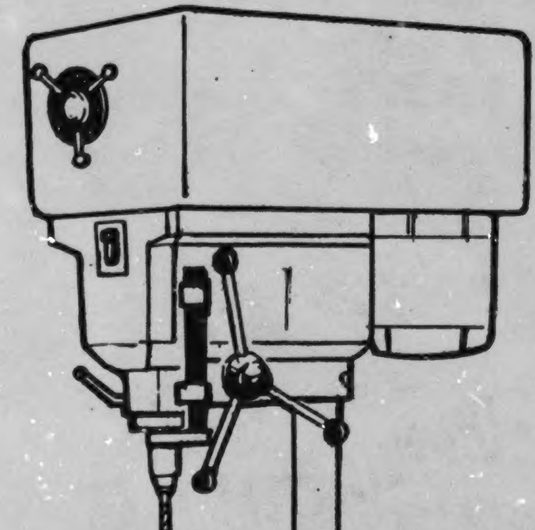
N. Do not misuse the drill press.

O. Report any damage to the instructor.

COMMON SHOP DRILL PRESSES

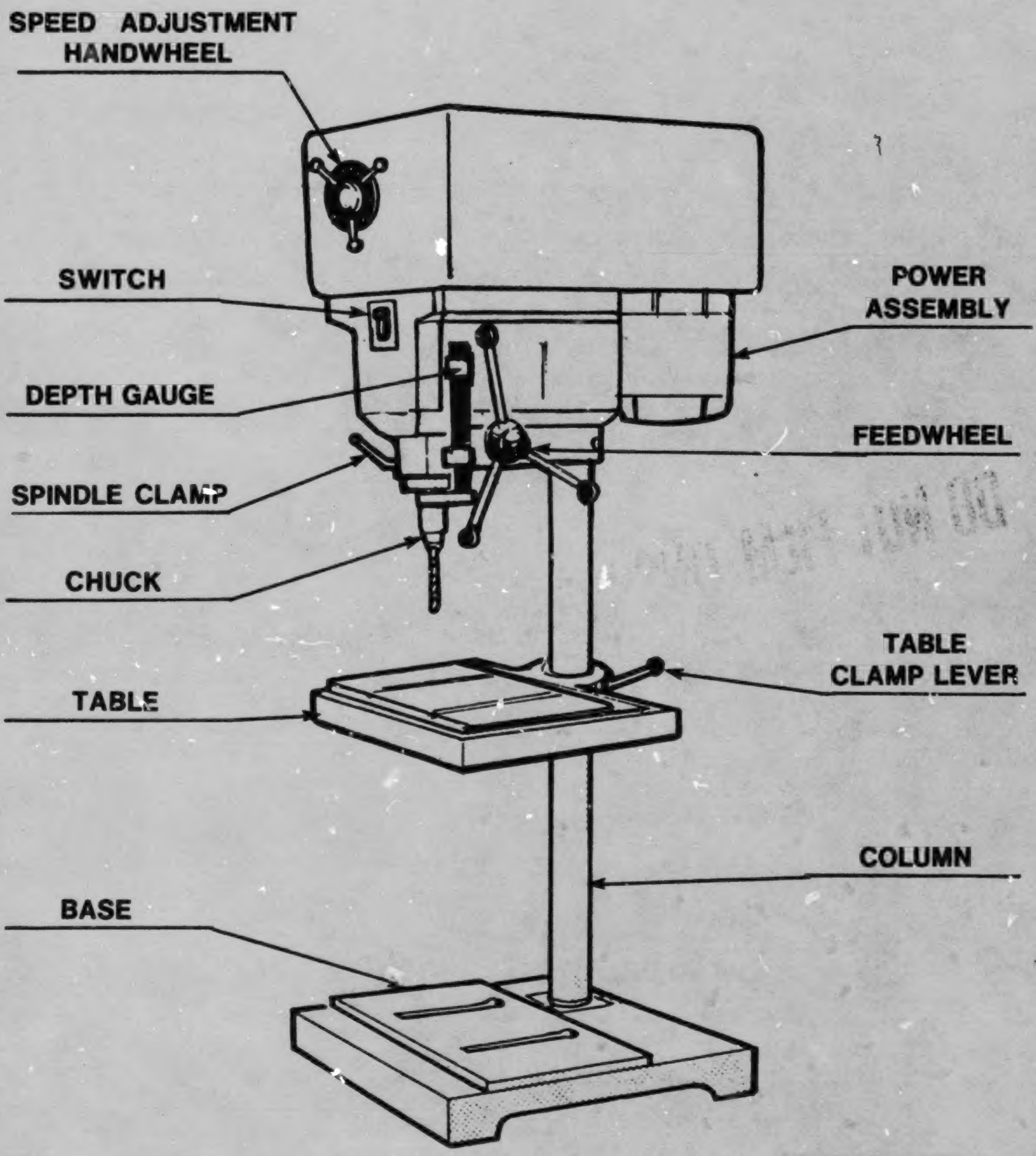


BENCH MODEL

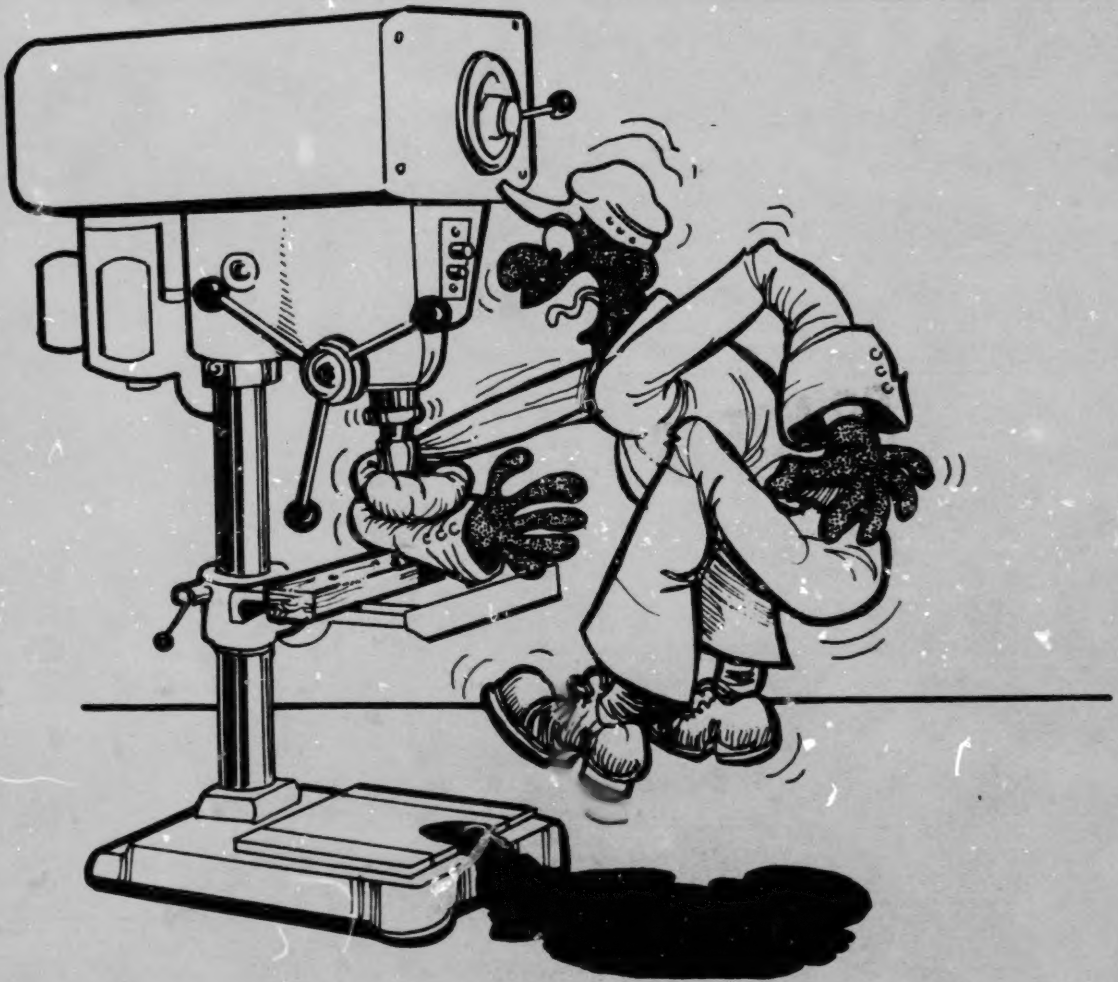


FLOOR MODEL

PARTS of a DRILL PRESS


SPEED ADJUSTMENT HANDWHEEL
SWITCH
DEPTH GAUGE
SPINDLE CLAMP
CHUCK
TABLE
BASE
POWER ASSEMBLY
FEEDWHEEL
TABLE CLAMP LEVER
COLUMN

PROPER USE of the DRILL PRESS



UNIT I

DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 1--IDENTIFY DRILL PRESS TERMS

Directions: Match the correct word or words on the right hand to the correct definition in the left column. Place the appropriate number in the space provided on the left.

____A. Process of forming a hole with a drill.

____B. A machine used for drilling holes.

____C. Used to fasten workpiece to table.

____D. Jobs performed.

____E. Used for cutting holes.

____F. Drill press which sits on a table.

____G. Drill press which sits on the floor.

____H. Supports cutting tool.

____I. Holds or clamps drill in place.

____J. Supports table.

____K. Distance from column to center of spindle.

____L. Used to measure hole depth.

____M. Turns power ON or OFF.

____N. Locks spindle in place.

____O. Used to adjust cutting speeds.

____P. Provides necessary power to drill press.

____Q. Locks table to column.

____R. Supports workpiece.

1. base
2. twist drill
3. size
4. chuck
5. spindle lock clamp
6. column
7. speed adjustment handwheel
8. power assembly
9. drill press
10. table
11. clamping device
12. table clamp lever
13. switch
14. floor type
15. drilling
16. bench drill press
17. operations
18. depth gauge

UNIT I

DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 2--EXPLAIN DRILL PRESS SAFETY

Directions: Answer the following questions with specific answers.

A. What can happen if you are not careful when using a drill press?

B. What should be used to remove metal chips from the drill press and workpiece? Why?

C. Why must you protect your eyes when performing a drilling operation?

D. Should you stop a drill press spindle with your hand? Explain.

E. Describe what could occur if you wear loose clothes or do not tie back hair when operating drill press.

CORRECTION

Oops! We goofed---but at least we caught it!

on pages 19 and 20 of UNIT I--DRILLS AND DRILL PRESSES, under item C. Figuring speeds, the correct copy should be this:

C. Figuring speeds

1. Simple formula-- $\text{RPM} = \frac{4 \times \text{CS}}{\text{D}}$

2. Abbreviations:
    - a. RPM--revolutions per minute
    - b. CS--cutting speed
    - c. FPM--feet per minute
    - d. D--diameter of drill

EXAMPLE: Obtain recommended cutting speed for drilling aluminum with 250 FPM cutting speed.

(1) Convert drill diameter--1/4 inch--to decimal-- .250

(2) Place figures in formula: $\text{RPM} = \frac{4 \times \text{CS}}{\text{D}}$

$$\text{RPM} = \frac{4 \times 250}{.250}$$

(3) Calculate:

$$\text{RPM} = \frac{4 \times 250}{.250} = \frac{1000}{.250} = 4000 \text{ RPM}$$

UNIT I

DRILLS AND DRILL PRESSES

INFORMATION SHEET 2--CUTTING SPEEDS AND CUTTING FLUIDS

I. Cutting speeds and feeds

A. Definitions

1. Cutting speed--The surface speed that the drill rotates.

   (NOTE: It is shown in *feet per minute*-FPM.)

2. Feed--The speed at which a cutter is fed into the work with each revolution.

3. RPM--Revolutions Per Minute.

   (NOTE: Cutting speed and feed determine the time required to drill a hole.)

B. Speed and feed table

1. Provides speed and feed recommendations for various materials.

2. Lists speeds for each drill size under RPM column.

3. Shows feeds for each type of metal.

4. Gives clues to use in checking correct manual feed on drill presses:

   a. Uniform chips--indicate drill is fed correctly.

   b. Chatter or scraping noise--indicate drill is dull, or is too slow.

   c. Chipped cutting edges, broken drills, and drill heating, even with coolant--show feed is too fast.

C. Figuring speeds

1. Simple formula--RPM = 4 x CS

2. Abbreviations

   a. RPM--revolutions per minute.

   b. CS--cutting speed.

   c. FPM--feet per minute.

   EXAMPLE: Obtain recommended cutting speed for drilling aluminum with 250 FPM cutting speed.

(1) Convert drill diameter 1/4" to .250 decimal fraction.

(2) Place figures in formula: $\text{RPM} = 4 \times \text{CS}$

$$\text{RPM} = \frac{4 \times 200}{.250}$$

(3) Calculate:

$$\text{RPM} = \frac{4 \text{x} 200}{.250} = \frac{800}{250} = 3200 \text{ RPM}$$

II. Cutting fluids

A. Purposes

1. To cool a drill during drilling so it will not lose its temper (hardness) and become dull.

2. To act as a lubricant to reduce friction at the cutting edge.

3. To reduce the tendency of chips to become welded to the lips.

4. To improve finish of holes.

5. To wash away chips from holes.

B. Types of cutting fluids

1. Cutting oil--Petroleum mineral oil base.

2. Emulsifiable oil--Mineral oil and water base.

    a. is mixed with water.

    b. has better coolant properties than cutting oils.

    c. contains rust inhibitors.

3. Other coolants and cutting fluids:

    a. kerosene--used in cutting aluminum and its alloys.

    b. compressed air--used when machining cast iron.

    c. cutting wax--developed for use as cutting compounds to be used with other cutting fluids.

SPEEDS for FRACTION-SIZE DRILL

Feet per Min.	30	40	50	60	70	80	90	100	110	120	130	140	150
Diam. (Inches)	Revolutions per Minute												
1/16	1833	2445	3056	3667	4278	4889	5500	6111	6722	7334	7945	8556	9167
1/8	917	1222	1528	1833	2139	2445	2750	3056	3361	3667	3973	4278	4584
3/16	611	815	1019	1222	1426	1630	1833	2037	2241	2445	2648	2852	3056
1/4	458	611	764	917	1070	1222	1375	1528	1681	1833	1986	2139	2292
5/16	367	489	611	733	856	978	1100	1222	1345	1467	1589	1711	1833
3/8	306	407	509	611	713	815	917	1019	1120	1222	1324	1426	1528
7/16	262	349	437	524	611	698	786	873	960	1048	1135	1222	1310
1/2	229	306	382	458	535	611	688	764	840	917	993	1070	1146
5/8	183	244	306	367	428	489	550	611	672	733	794	856	917
3/4	153	203	255	306	357	407	458	509	560	611	662	713	764
7/8	131	175	218	262	306	349	393	436	480	524	568	611	655
1	115	153	191	229	267	306	344	382	420	458	497	535	573
1 1/8	102	136	170	204	238	272	306	340	373	407	441	475	509
1 1/4	92	122	153	183	214	244	275	306	336	367	397	428	458
1 3/8	83	111	139	167	194	222	250	278	306	333	361	389	417
1 1/2	76	102	127	153	178	204	229	255	280	306	331	357	382
1 5/8	70	94	117	141	165	188	212	235	259	282	306	329	353
1 3/4	65	87	109	131	153	175	196	218	240	262	284	306	327
1 7/8	61	81	102	122	143	163	183	204	224	244	265	285	306
2	57	76	95	115	134	153	172	191	210	229	248	267	287
2 1/4	51	68	85	102	119	136	153	170	187	204	221	238	255
2 1/2	46	61	76	92	107	122	137	153	168	183	199	214	229
2 3/4	42	56	69	83	97	111	125	139	153	167	181	194	208
3	38	51	64	76	89	102	115	127	140	153	166	178	191

*Courtesy of Cleveland Twist Drill Co.

SPEEDS FOR FRACTION-SIZE DRILLS*

SUGGESTED DRILL SPEEDS

SUGGESTED DRILL SPEEDS

Material to be Drilled	Cutting Speed (Surface Feet per minute)
Aluminum and its alloys	200-300
Bakelite	100-150
Brass and bronze, soft	200-300
Carbon, pure(carbide drills)	70-150
Cast iron, soft	100
Cast iron, hard	100-150
Magnesium and its alloys	250-400
Malleable iron	80-90
Nickel and monel	40-60
Steel, machinery	80-100
Steel, annealed	70-80
Steel, tool	50-60
Steel, forged	50-60
Steel, alloy (300 to 400 Brinnel)	20-30
Steel, stainless, free machining	30-40
Steel, stainless, hard	30-40
Steel, manganese	15

Source: American Machinist. Speeds shown above are for high-speed steel drills. Carbon steel drills should be run at from 40 to 50 per cent of those for high-speed steel drills. These are recommended speeds; the best speed in each case must be based on the specific conditions, material, set-up, etc.

UNIT I

DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 3--IDENTIFY FEED AND SPEED TERMS

Directions: Match the correct word or words in the right-hand column to the definition in the left-hand column. Place the correct number in the space provided on the left.

____A. The speed that rotates into the stock the drill.

____B. Provides recommended speed and feed.

____C. Uniform metal chips.

____D. Chatter, scraping.

____E. Revolutions per minute (abbreviation)

____F. Cutting speed (abbreviation)

____G. Feed per minute (abbreviation)

____H. $RPM = \frac{4 \times CS}{D}$

____I. The speed with which the drill is moved into the work.

____J. Cools and lubricates drills.

____K. Used when cutting aluminum.

____L. Used when cutting cast iron.

____M. One function of cutting fluids.

____N. RPM formula.

1. feed
2. cutting fluid
3. chips from proper feed
4. $\frac{4 \times CS}{D}$
5. RPM formula
6. cutting speed
7. caused by dull drill
8. speed and feed table
9. CS
10. kerosene
11. compressed air
12. RPM
13. FPM
14. wash chips away from hole
15. SFM

UNIT I

DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 4--SELECTING CUTTING SPEEDS AND FIGURING RPM

Directions: Using the cutting speed and speed tables shown in Transparencies 4 and 5, complete the following problems. Use the formula $\text{RPM} = \frac{4 \times CS}{D}$ and show your work. Select lower values in tables.

A. What cutting speed should you use in figuring the RPM when drilling each of the following materials:

CUTTING SPEED

1. Soft cast iron ____________________
2. Aluminum ____________________
3. Annealed steel ____________________
4. Malleable iron ____________________
5. Forged carbon steel ____________________

B. Figure RPM that should be used when drilling low carbon steel with a ¼-inch diameter drill bit. Use the RPM formula given in the directions.

C. Figure the RPM setting for a variable steel drill press if a hole one-inch deep is to be drilled in aluminum alloy. The drill size is 1 inch.

D. Figure the RPM to be used when drilling in malleable iron with a 3/8" drill bit.

HINT: Change the fraction to a decimal before dividing.

E. Using the tables, select the RPM setting for each of the following materials when drilling with high-speed drills.

	MATERIAL	DRILL SIZE	RPM
1.	Stainless	1/4"	
2.	Bronze	3/4"	
3.	Tool steel	7/16"	
4.	Steel alloy	1 3/4"	
5.	Hard cast iron	7/8"	

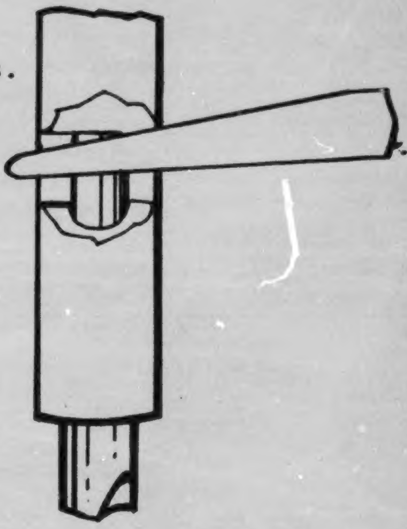
UNIT I

DRILLS AND DRILL PRESSES

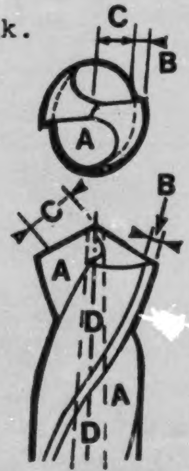
INFORMATION SHEET 3--TWIST DRILLS AND DRILLING ACCESSORIES

I. Twist drills

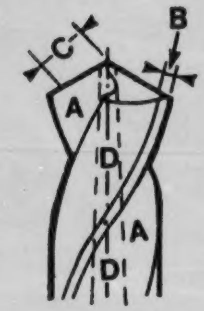
- A. Parts of a twist drill (TM-5)
  - 1. Point--Cone-shaped end that does the cutting. Consists of:
    - a. Dead center--Sharp edge at the tip of drill. Center of drill.
    - b. Lips--Cutting edges of drill.
    - c. Heel--Portion of the point opposite the cutting edge.
  - 2. Shank--End of drill bit that is attached to the drill press.
    - a. Straight--Used with a chuck.
    - b. Tapered--Have self-holding tapers.
      - (1) Morse taper--No. 1 to No. 5 tapers that fit directly into drill press spindle.
      - (2) Tang--Is on tapered shank which fits into the spindle slot.
      - (3) Tapered sleeve--a device to adapt different sizes of drill shanks.



  - 3. Body--Portion between point and the shank. Consists of:
    - a. Flutes--Spiral grooves running the length of drill body.
      - (1) Help form cutting edge.
      - (2) Curl chips tightly for easy removal.
      - (3) Form channels for chip removal.



(4) Allow coolants and lubricants to flow to cutting edge.



b. Margin--Narrow strip extending back length of drill to form the full diameter of the drill bit.

c. Body clearance--The reduced part that cuts down friction between wall of hole and drill.

d. Web--Metal column that separates the flutes, increases thickness towards the shank to give strength.

B. Types of drills

1. Carbon steel drill--Used for soft materials.

2. High speed steel--Used for hard materials.

C. Sizes of drills

(NOTE: Drill size charts show drill diameters in numbers, letters, fractions, and metric sizes.)

1. Number--From #80 to #1.

(NOTE: 0.135 in. to 0.2280 in. diameters.)

2. Letters--A to Z.

(NOTE: -.234 in. to 0.413 in. diameters.)

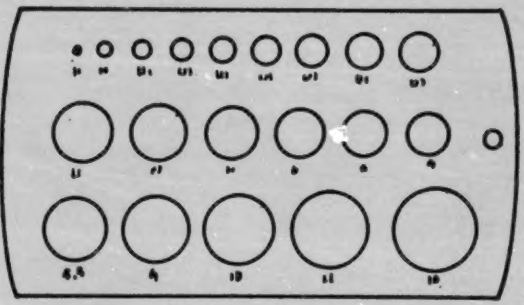
3. Fractions--1/64 to 63/64 in. diameters.

4. Metric--3mm to 76mm.

(NOTE: 0.1181 to 2.9921 in. diameter.)

5. Twist drill gages are used to check the sizes of drill bits.

(NOTE: Gages are available in numbers, letters, fractions, and metric sizes.)



II. Work holding devices

A. Purpose

1. To clamp work solidly while operation is performed.

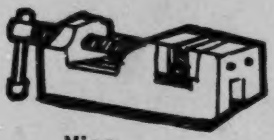
2. To prevent injury to drills and machine.

3. To prevent injuries.

B. 1. Vises--Safest of workholding devices when bolted to table.

a. Should have wood or flat stock placed under work to prevent damage to vise.

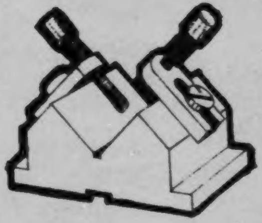
b. Require the use of parallels (hardened rectangular bars) to raise work in the vise jaws.


Vise

2. V-blocks--Used to support round work when drilling.

a. Made in various shapes.

b. Some have clamps to assist in holding.


V-Block

3. T-slot bolts--Fit into table slots.

a. Used with washer and nut.

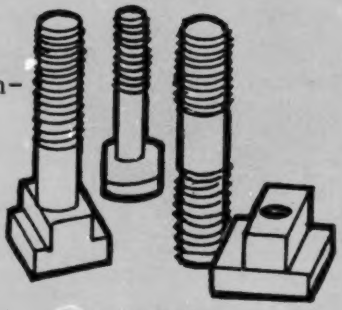
b. Come in various lengths.

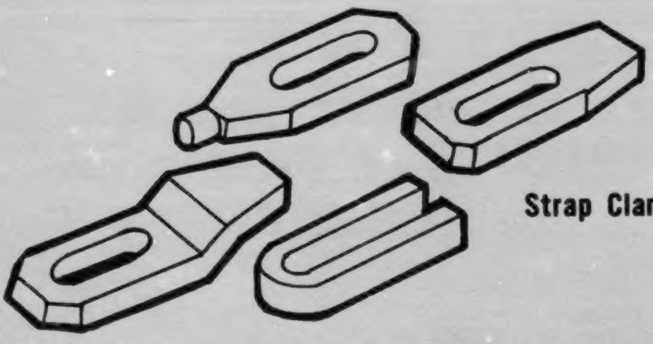
4. Strap-clamps--Used for clamping unevenly shaped parts.

a. Come in various lengths.

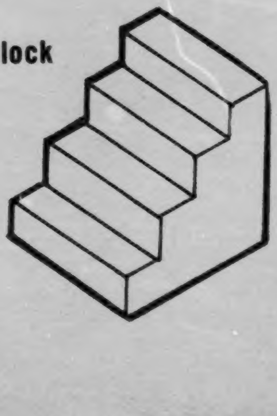
b. Used with T-bolts.

5. Step blocks--Support strap clamps opposite the work at any level.


T-Slot Bolts

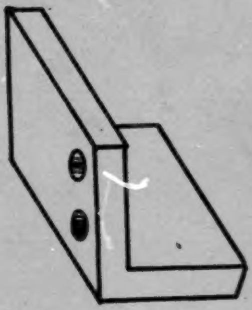

Strap Clamps

Step Block



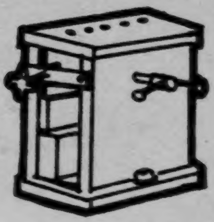
6. Angle plate--Used where work needs to be clamped to a vertical support.

7. Drill jigs--Used when holes are to be drilled in a number of identical pieces.

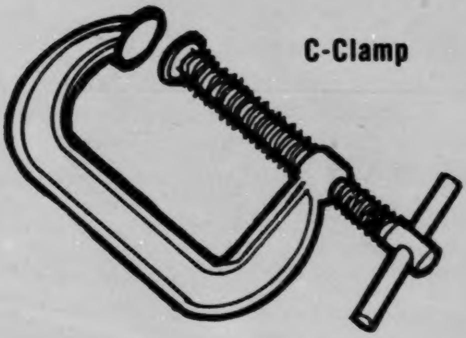


Angle Plate

8. C-clamps--Used for clamping flat stock.

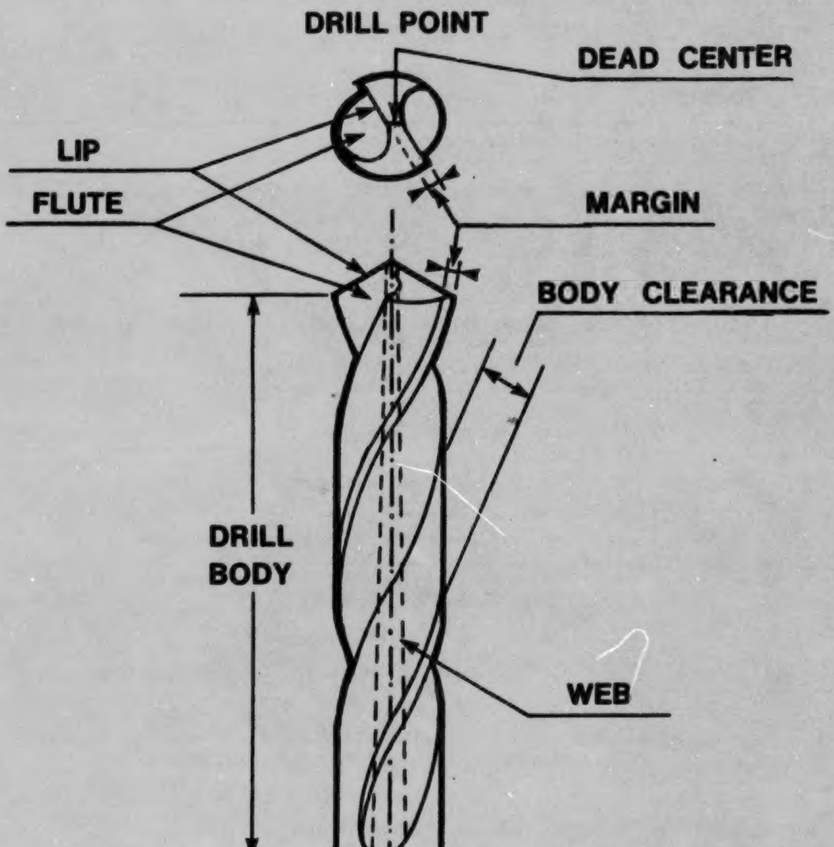


Drill Jig



C-Clamp

PARTS of a TWIST DRILL


DRILL POINT
DEAD CENTER
LIP
FLUTE
MARGIN
BODY CLEARANCE
DRILL BODY
WEB
AXIS of DRILL
SHANK
TANG

UNIT I

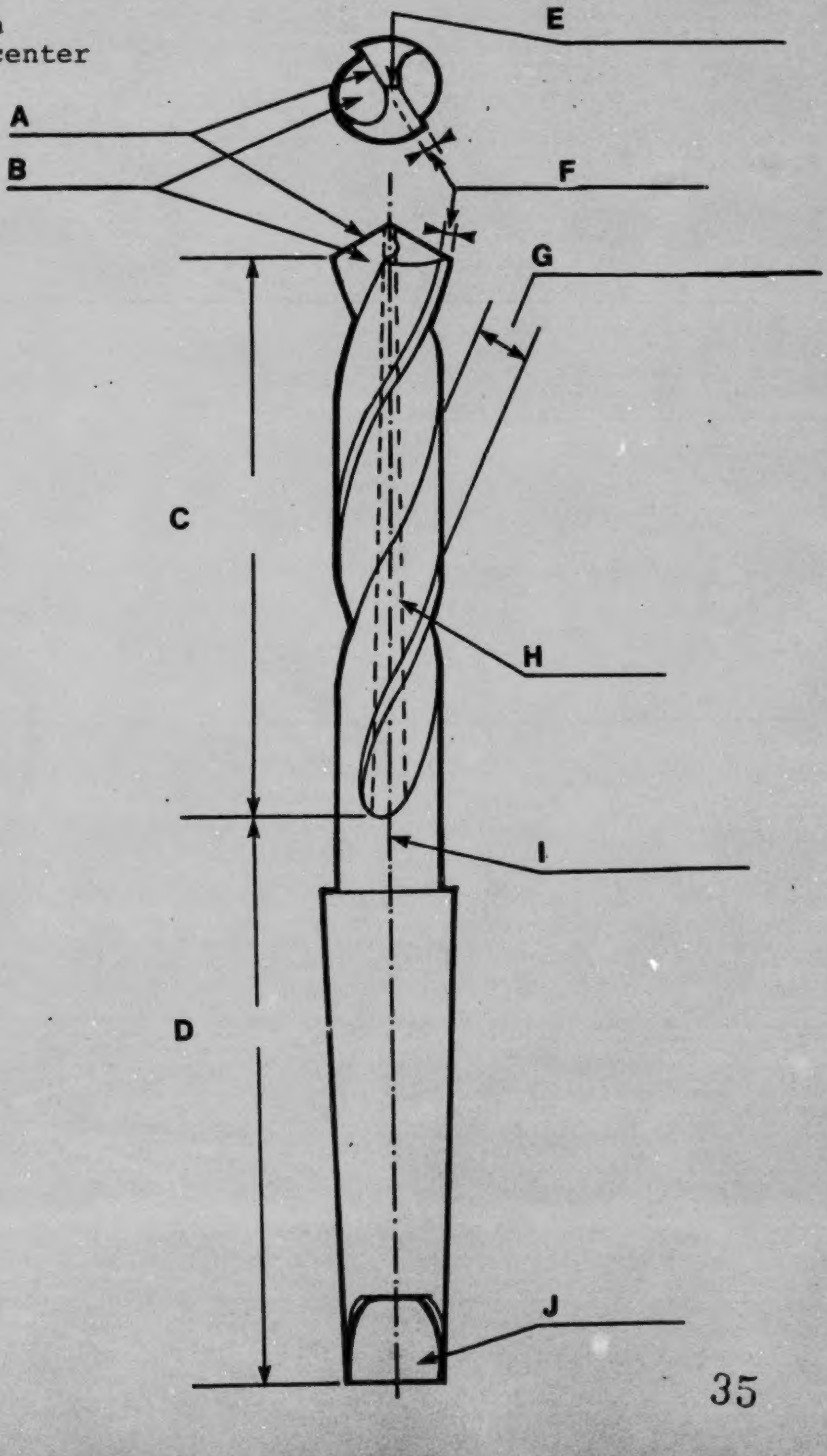
DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 5--IDENTIFY THE PARTS OF A DRILL

Directions: Identify the drill parts and place the correct answers by each letter provided.

lip
margin
dead center
flute
web

axis
shank
drill body
tang
body clearance



UNIT I

DRILLS AND DRILL PRESSES

ASSIGNMENT SHEET 6--IDENTIFY DRILLING ACCESSORIES

Directions: Match the correct word or words in the right-hand column to the definition given in the left-hand column. Place the correct number in the space provided on the left.

____A. To hold work in place solid during operations.

____B. Most commonly used holding device.

____C. Hardened stock to raise work in vise.

____D. Used for supporting round work.

____E. Fit in worktable slots.

____F. Use with T-bolts.

____G. Supports strap clamps opposite the work.

____H. Used where work needs to be clamped to a vertical support.

____I. Used when holes are drilled in a number of identical places.

____J. Used for clamping flat stock.

1. C-clamp
2. drill jigs
3. step blocks
4. vise
5. purpose of holding device
6. angle block
7. parallels
8. strap clamps
9. V-blocks
10. T-bolts

UNIT I

DRILLS AND DRILL PRESSES

INFORMATION SHEET 4--DRILLING OPERATIONS

I. Operations performed on the drill press.

  A. Drilling--To produce a hole in metal with a drill bit.

  B. Countersinking--To shape a drilled hole in material with a cone-shaped tool to provide a recess for a flat head screw or bolt.

  C. Counterboring--To drill a second larger hole to a specified depth, using the same center as the original hole.

  (NOTE: This is done to set socket head screws below the work surface.)

  D. Tapping--Is done with hand tap and wrench to cut internal threads in holes.

  (NOTE: A 60° center is chucked in the drill press for alignment.)

  E. Spot-facing--Making circular spots on uneven surfaces to produce a finished flat surface for a head of a bolt or nut.

  (NOTE: A counterbore is usually used.)

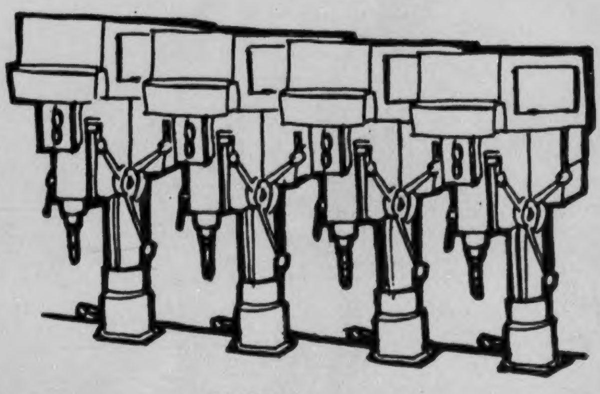
  F. Boring--To make a hole larger, using a single-pointed cutting tool.

  G. Spot finishing--A means of polishing and finishing surfaces with numerous circular marks, using a wood dowel and grinding compound.

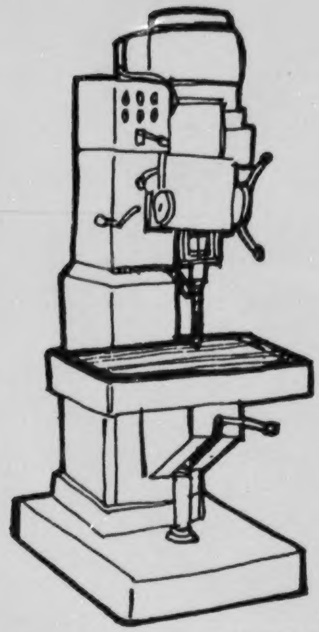
  H. Reaming--Used to finish a drilled hole to an accurate size.

II. Other drilling machines

  A. Gang drill--A drilling machine with several drilling spindles fastened in line to a single long table. Is used in mass production in doing a series of operations, one after the other. One operation may often require several different drill sizes. May have two or more spindles, with 8-10 spindles quite common.

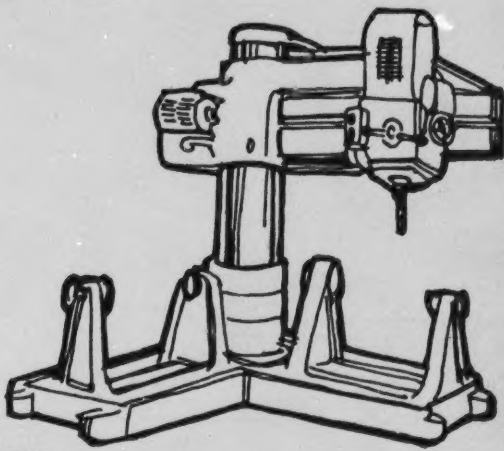


GANG



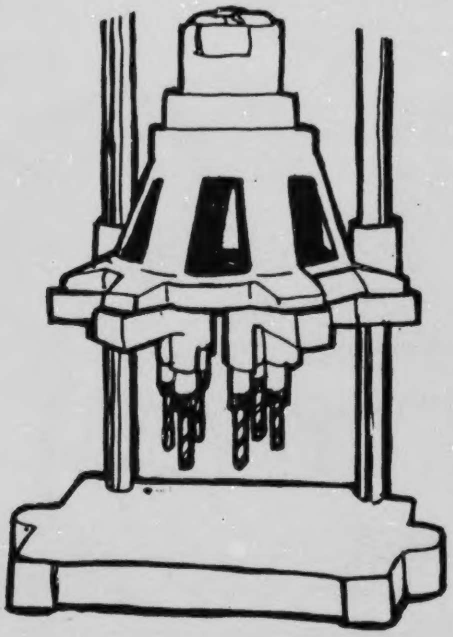
UPRIGHT

B. Upright drill--Similar to floor-type drill press used in medium heavy-duty drilling. It usually has a gear-driven mechanism for different spindle speeds and an automatic or power feed device. It will receive larger drills and cutters than the standard bench and floor-type drill presses.



RADIAL

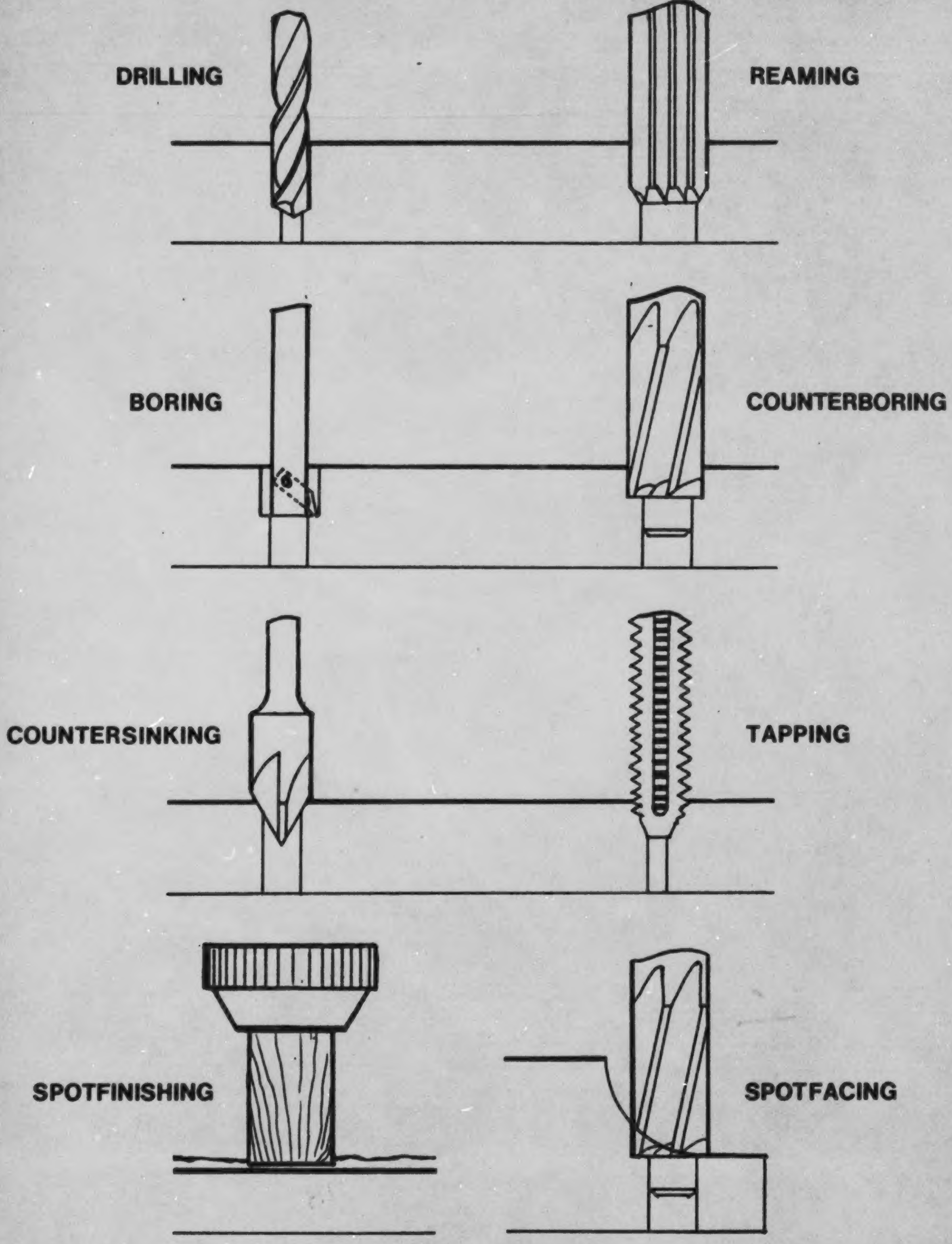
C. Radial drilling machine--Handles large workpieces that cannot be moved easily. It has a large arm extending out from the column which can be raised or lowered, and which also swings in a complete circle around the column. The drilling head moves back and forth on this arm.



MULTI-SPINDLE

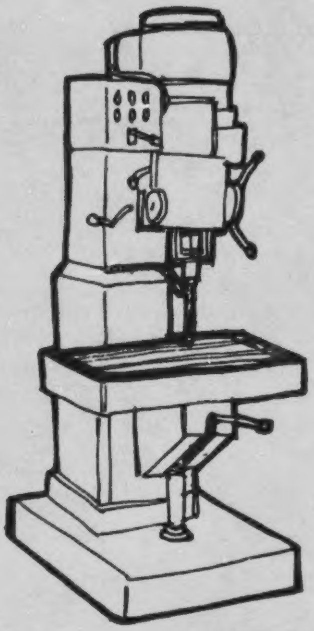
D. Multiple-spindle drill head machine--May have from four to 48 or more spindles which are driven by one gear drive in the head. These are mass-production drilling machines. Some have several drill heads, with many spindles making it possible to drill as many as 100 holes at one time.

OPERATIONS of the DRILL PRESS

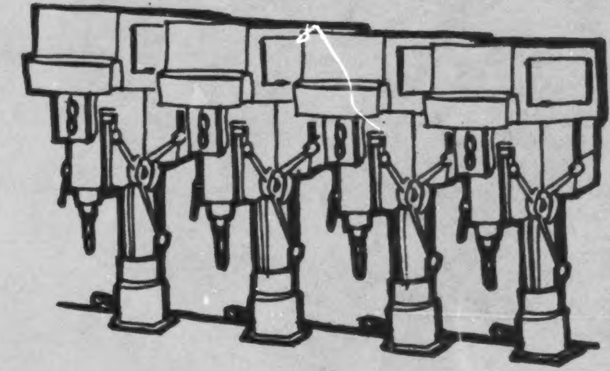

DRILLING
REAMING
BORING
COUNTERBORING
COUNTERSINKING
TAPPING
SPOTFINISHING
SPOTFACING

TM-7

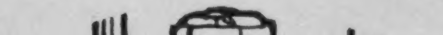
OTHER DRILLING MACHINES



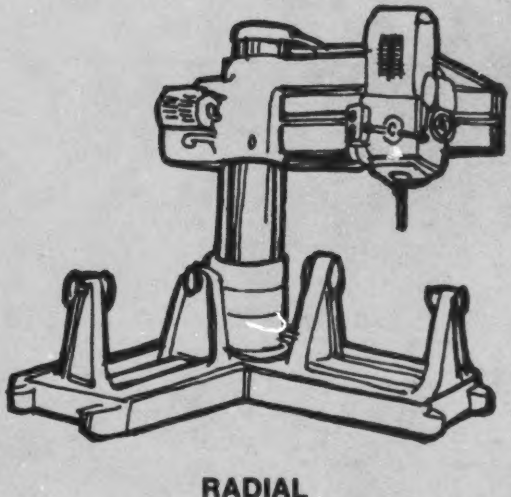
UPRIGHT



GANG



MULTI-SPINDLE



RADIAL

UNIT I

DRILLS AND DRILL PRESSES

JOB SHEET 1--SHARPEN A TWIST DRILL BIT

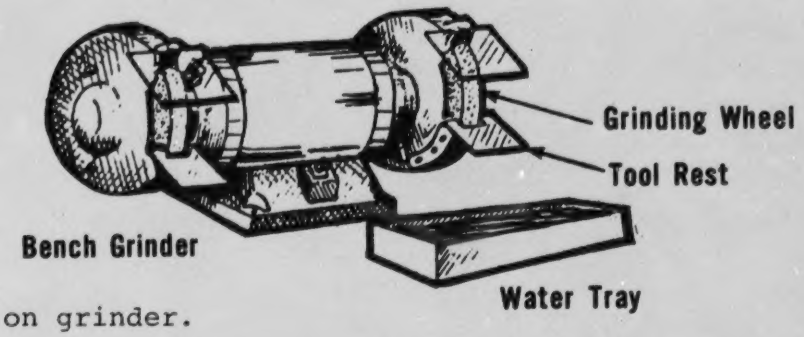
I. Tools and materials

- A. Dull drill bit
- B. Bench grinder
- C. Water tray
- D. Safety glasses
- E. Drill bit gauge or protractor
- F. Oilstone

II. Procedure

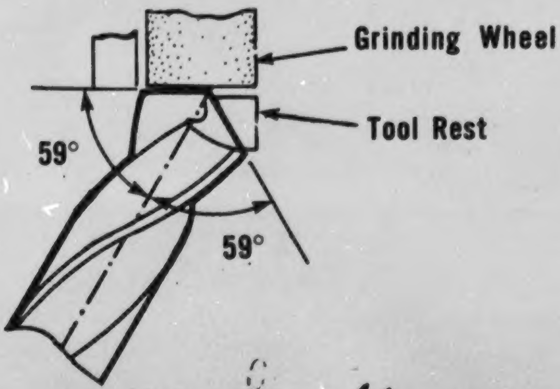
- A. Put on safety glasses.
- B. Adjust tool rest to proper clearance.

  (NOTE: Proper clearance is approximately 1/8" from the wheel.)


Grinding Wheel
Tool Rest
Bench Grinder
Water Tray

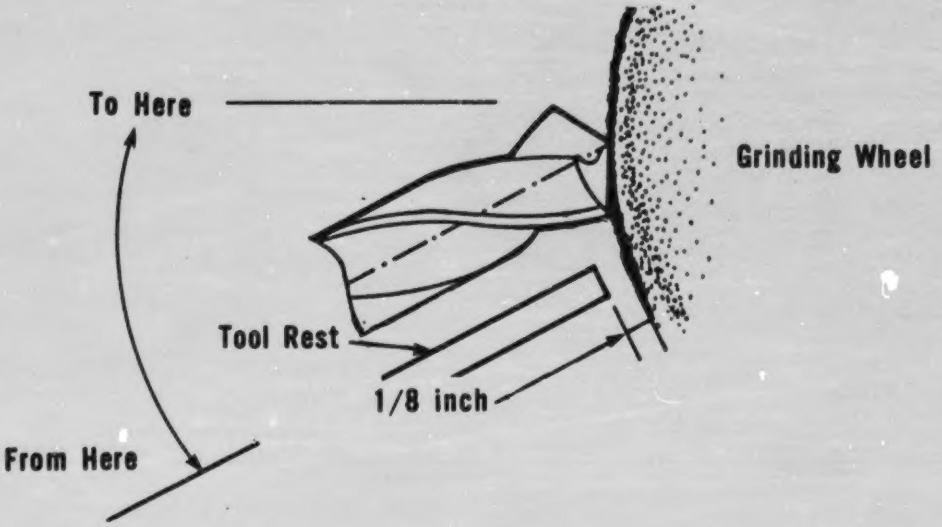
- C. Turn on grinder.
- D. Place drill bit on tool rest at an angle of about 59°.

  CAUTION: Do not grind on the side of the wheel.

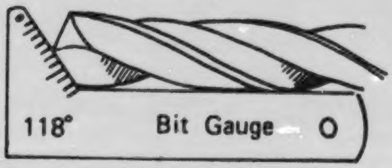

Grinding Wheel
Tool Rest
59°
59°

E. Grind one lip of the drill bit by rolling the bit to the right and up.

(NOTE: This rolling of the drill bit provides back clearance.)

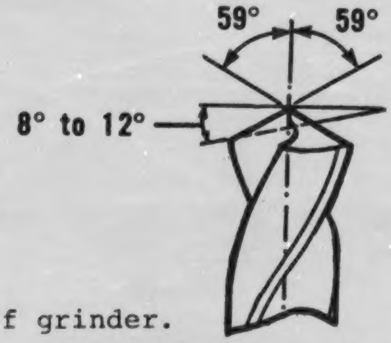

To Here
Grinding Wheel
Tool Rest
1/8 inch
From Here

F. Check the correct angle with a drill bit gauge.


118°
Bit Gauge
O

G. Grind and check the other drill bit lip.

(NOTE: The point of the drill should be centered on the bit when grinding is finished.)



H. Turn off grinder.

I. Hone cutting edges of the drill bit to remove burrs.

J. Recheck all cutting angles.

K. Clean up work area.

UNIT I

DRILLS AND DRILL PRESSES

JOB SHEET 2--DRILL VARIOUS SIZE HOLES

I. Tools and materials

- A. Correct-size drill
- B. Drill press
- C. C-clamp
- D. Brush
- E. Cutting oil
- F. Flat file
- G. V-block
- H. Step block
- I. T-slot bolt and strap
- J. Center punch
- K. Hammer

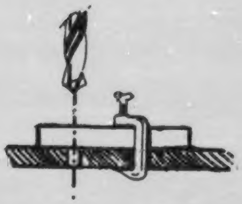
II. Procedure

A. Drilling holes up to 1/2" diameter.

1. Determine hole location from blueprint or drawing.
2. Layout properly and center punch hole locations where lines intersect.

   (NOTE: Do not center punch metal on the drill press table.)
3. Secure the correct drill.
   - a. Check for correct size.
   - b. Check for sharpness.
4. Secure work securely to the worktable with the C-clamp.

   (NOTE: Use a board under the work if the drill is not aligned with the hole in the worktable.)



5. Check for center (on critical jobs).

    a. Wiggler or center finder method.

    b. Proof circles method.

6. Install drill

    CAUTION: Be sure to remove the chuck key.

7. Calculate proper speed and adjust the drill press.

8. Turn power on and observe how drill runs.

    (NOTE: If drill wobbles, it may be bent or has been placed in chuck off-centered.)

9. Turn power ON, apply cutting fluid liberally, and start the cut.

10. Apply even feed pressure, watching for signs of poor cutting:

    a. Squeak, overheating--dull drill.

    b. Chip buildup on dead center--poor cuts, which build up heat. Remove by raising and lowering drill into hole several times.

    c. Chips in flutes--causes drill binding and slows machine. Clean with brush.

11. Clear metal chips and add cutting oil each time the drill is removed from the hole.

12. Ease up feed as drill starts to cut through the work.

    (NOTE: Easing the pressure will prevent drill from digging in.)

13. Remove drill from the hole and turn OFF power to machine.

    CAUTION: Let the spindle stop by itself.

14. Clear chips with brush.

    CAUTION: Do not remove chips with your hands.

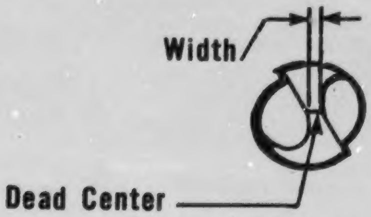
15. Unclamp work and remove all burrs with file.

16. Clean the machine thoroughly and return the drill to its proper place.

B. Drilling holes larger than 1/2" diameter.

(NOTE: Since drills over 1/2" are hard to start and require greater pressure to drill, pilot holes are drilled first to reduce pressure and guide the large drill through the work.)

1. Check the width of the dead center on the large drill to be used.



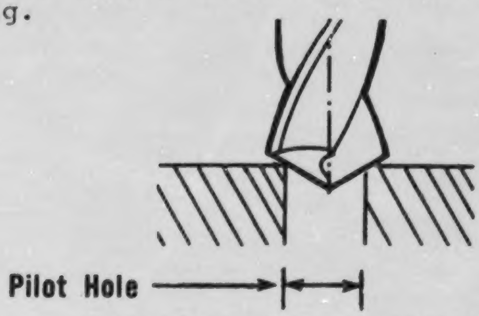
2. Select a drill bit (pilot drill) the width of the dead center of the larger drill.

3. Drill a pilot hole on center of the location for the larger hole to be drilled.

   (NOTE: Follow procedures under part A Drilling holes up to 1/2" diameter.)

4. Replace the smaller drill with the larger size.

5. Check the larger drill for proper alignments and speed setting.



6. Make sure the drill will not drill into the table.

   (NOTE: Place a block of wood under the work.)

7. Turn on the power and drill slowly through the work.

8. Apply cutting oil and remove the drill from the hole often.

9. Ease up feed as the drill starts to cut through.

10. Remove the drill from the hole and turn OFF power.

11. Clear chips with a brush.

12. Unclamp work and remove all burrs with a file.

13. Clean the machine thoroughly and return the drills to the proper place.

C. Drilling blind holes.

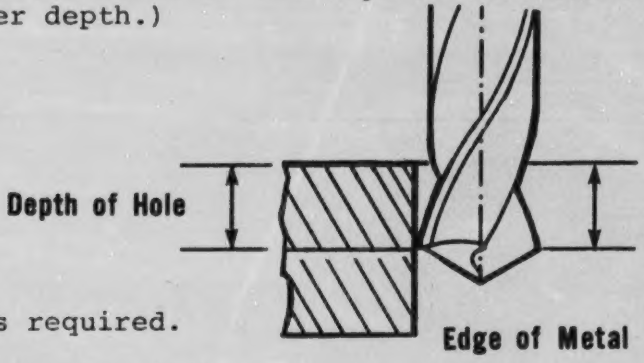
(NOTE: Blind holes are holes that are not drilled all the way through the material.)

1. Determine the depth of the hole to be drilled.

(NOTE: The depth of the hole is measured by the distance the full diameter of the drill goes into the work.)

2. Set the depth stop to the proper depth to be drilled.

(NOTE: Align the drill on the edge of the work at the proper depth.)



3. Drill hole as required.

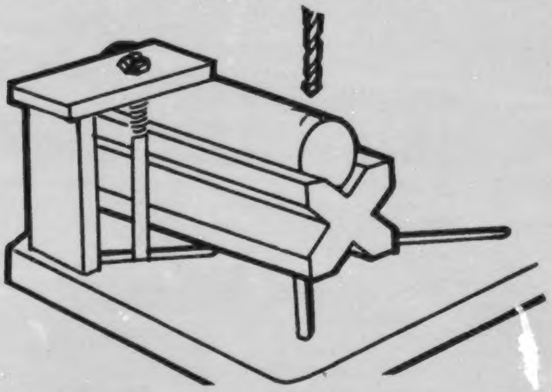
D. Drilling holes in round stock

(NOTE: Problems can be eliminated if round stock is held in V-blocks.)

1. Locate hole with layout lines.

2. Centerpunch centerpoint of hole.

3. Secure V-block with stock to the worktable.



4. Align the drill point with the punch mark on the round stock.

5. Drill hole as required.

DRILLS AND DRILL PRESSES

JOB SHEET 3--REAM A DRILLED HOLE

I. Tools and materials

   A. Drill bit

   B. Reamer

   C. Drill press

   D. Brush

   E. Drill press vise

   F. File

   G. Small hole gauge

   H. 0-1 micrometers

II. Procedure

   A. Select the reamer for the required hole size.

   B. Select the correct drill size for drilling the required hole size.

   (NOTE: Use a drill sized 1/64" under the finished hole size.)

   C. Secure the work to the table with the best-suited clamping method.

   D. Set the speed of the drill press for the drill size.

   E. Drill the pilot hole for the reamer.

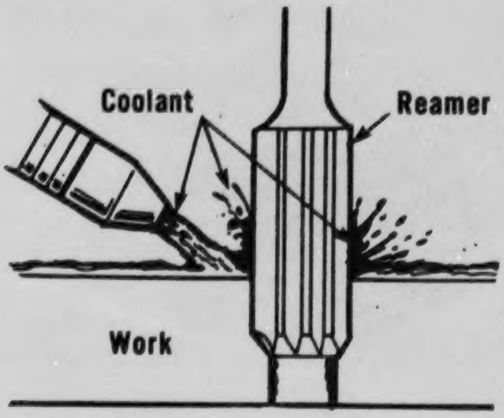
   F. Remove the drill bit and place the reamer in the chuck.

   CAUTION: Check the reamer for clearance when it goes through the hole.

   G. Select the speed for the reamer at one-half that used for the drill.

H. Turn the power to ON and feed the reamer into the hole.

(NOTE: The reamer should be fed in quickly and smoothly.)



I. Use the coolant on the reamer as it is fed completely through the hole.

J. Back the reamer out of the hole.

K. Remove the burrs with a file.

L. Check the hole for proper size.

(NOTE: If the hole is undersized, adjust the reamer or select a reamer the size required and ream the hole.)

M. Clean up the drill press and return tools to the proper place.

UNIT I

DRILLS AND DRILL PRESSES

ANSWERS TO ASSIGNMENTS

Assignment Sheet 1

A. 15
B. 9
C. 11
D. 17
E. 2
F. 16
G. 14
H. 1
I. 4
J. 6
K. 3
L. 18
M. 13
N. 5
O. 7
P. 8
Q. 12
R. 10

Assignment Sheet 2

A. One can receive serious cuts and scratches, lose your fingers, hands, eyes, and other parts of your body.

B. A brush, because metal chips are sharp and will cause serious cuts.

C. Safety goggles or face shield.

D. Never.

E. You can be caught by moving parts which will pull you into the machine.

F. Never. Because drills can bind into workpiece and create a "Merry-Go-Round" which can seriously hurt you.

G. Report all injuries immediately so they can be treated.

H. One must first turn off the power of the drill press and let it come to a complete stop.

I. The key which fly out once the power is turned on, causing serious injuries.

J. It prevents damage to drills and foot injuries should they fall out from the chuck.

Assignment Sheet 3

A. 6
B. 8
C. 3
D. 7
E. 12
F. 9
G. 13
H. 5
I. 1
J. 2
K. 10
L. 11
M. 14
N. 4

Assignment Sheet 4

A. 1. 100

2. 200

3. 70

4. 80

5. 50

B. 1280

C. 800

D. 1066

E. 1. 458

2. 357

3. 437

4. 65

5. 306

Assignment Sheet 5

A. Dead center

B. Body clearance

C. Margin

D. Web

E. Axis

F. Shank

G. Tang

H. Drill body

I. Flute

J. Lip

Assignment Sheet 6

A. 5

B. 4

C. 7

D. 9

E. 10

F. 8

G. 3

H. 6

I. 2

J. 1

UNIT I

DRILLS AND DRILL PRESSES

TEST PART 1

1. Match the terms associated with drills and drilling to the correct definition. Place the number of each term on the right in the correct blanks on the left.

____a. The jobs performed.

____b. Used to fasten work pieces to the table.

____c. Forming a hole with a drill.

____d. A machine used for drilling holes in different materials.

____e. The cutting tool used in a drill press for drilling holes.

1. Drilling
2. Twist drill
3. Drill press
4. Clamping devices
5. Operations

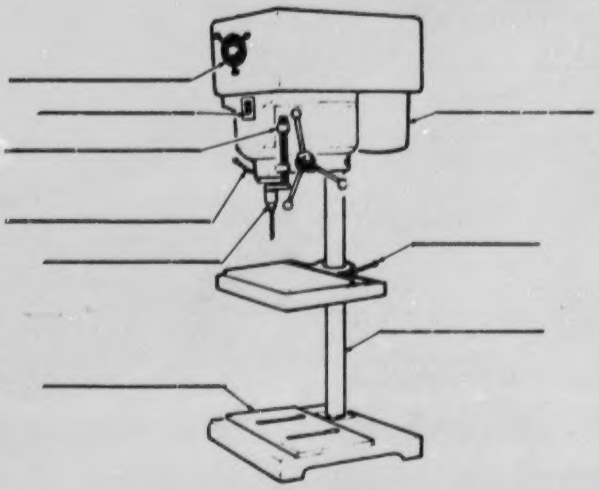
2. Name the two types of common shop drill presses.

a.

b.

3. Identify the parts of a drill press by labeling the illustration below.

Chuck
Base
Table clamp lever
Column
Power assembly
Switch
Speed adjustment handwheel
Depth gauge
Spindle lock clamp



UNIT I

DRILLS AND DRILL PRESSES

TEST PART 2

1. Explain the use of cutting speeds and feeds by circling the word or words that best completes each sentence below.

   a. The surface speed that the drill rotates is called the

      1. feed.
      2. cutting speed.
      3. RPM.

   b. The cutting speed of a drill is shown in

      1. revolutions per minute.
      2. inches.
      3. feet per minute.

   c. The speed at which a cutter is forced into the work with each revolution is the

      1. operation.
      2. feed.
      3. drilling ability.

   d. The speed and feed tables provide the drill operator with information about

      1. the length of the drill bit.
      2. the size of the drill press.
      3. the recommended feed and speed for drilling various types of metal.

   e. Correct feed of a properly sharpened drill bit into the work will most likely make

      1. uniform chips.
      2. chatter.
      3. chipped cutting edges on the drill.

   f. The proper formula for figuring RPM of a drill when you do not have a table is:

      1. $\text{RPM} = \frac{4 \times D}{CS}$
      3. $\text{RPM} = \frac{4 \times CS}{D}$
      2. $\text{RPM} = \frac{4 \times \text{length of drill}}{CS}$

g. The abbreviation CS stands for

   1. cutting speed
   2. diameter of the drill
   3. cutting surface

h. The RPM used for drilling a 1 inch hole in metal with a cutting speed of 50 surface feet per minute would be:

   1. 100 RPM
   2. 200 RPM
   3. 300 RPM

2. List three purposes of cutting fluids.

   a.

   b.

   c.

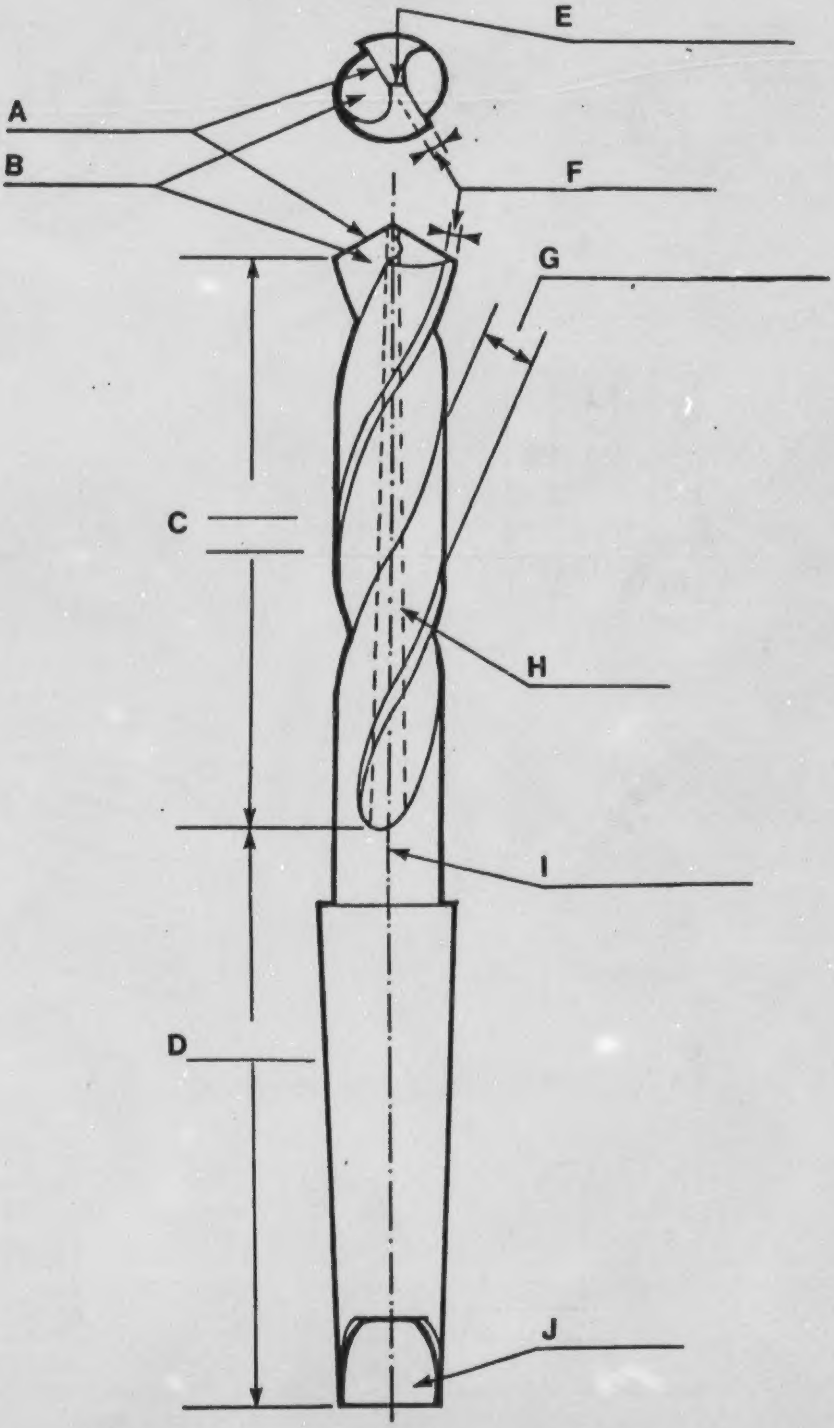
UNIT I

DRILLS AND DRILL PRESSES

TEST PART 3

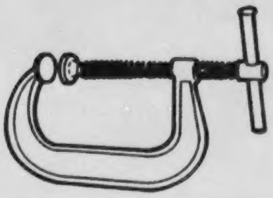
1. Identify the parts of the twist drill from the drawing below. Write the name of each part in the blank provided.

Flute
Dead center
Drill body
Tong
Web
Axis
Lip
Body clearance
Margin
Shank

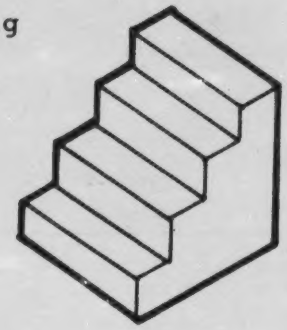


2. Identify the accessories used on the drill press. Write the name of each in the blanks provided.

V-block
Angle plate
T-slot bolt
C-clamp
Strap-clamp
Step block
Vise
Drill jig



a. ____________________



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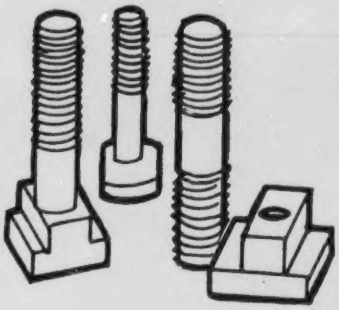
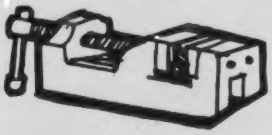
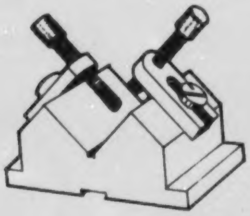


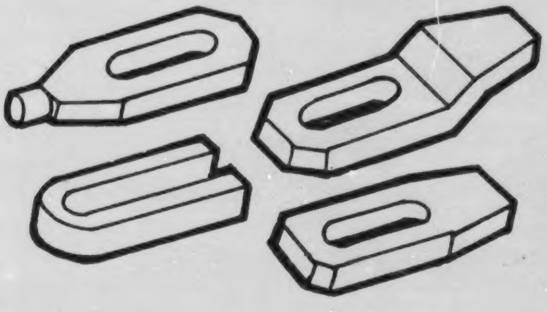
c. ____________________



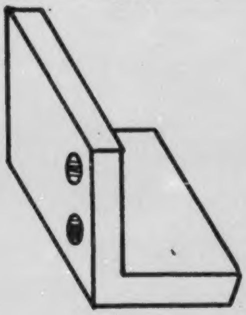
d. ____________________



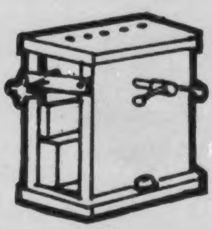
e. ____________________



f. ____________________



g. ____________________



h. ____________________

UNIT I

DRILLS AND DRILL PRESSES

TEST PART 4

1. Point out the operations that can be performed on the drill press by writing the number of each operation listed on the right in the correct blank.

____a. To finish a drilled hole to an accurate size.

____b. To make a hole larger with a single-pointed cutting tool.

____c. To cut internal threads in a hole.

____d. To finish and polish surfaces with numerous circular marks.

____e. To produce a hole in metal with a drill bit.

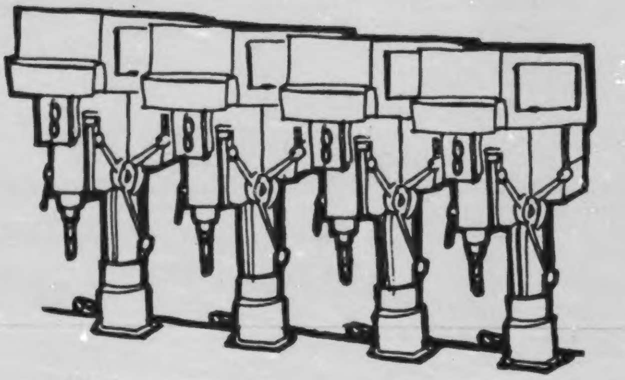
____f. To shape the opening of a drilled hole with a cone-shaped tool to provide a recess for a flat head screw.

____g. To drill a second larger hole to a specified depth using the same center as the first hole.

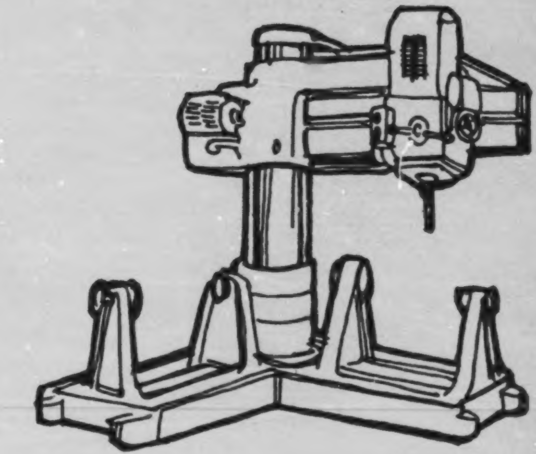
1. Boring
2. Drilling
3. Tapping
4. Spot finishing
5. Reaming
6. Counterboring
7. Countersinking

2. Identify the other drilling machines used in industry by labeling each picture below.

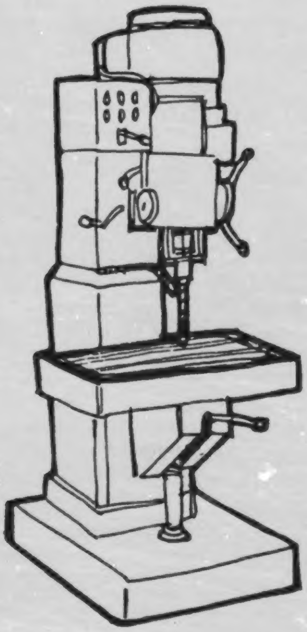
Upright	Multispindle
Gang	Radial



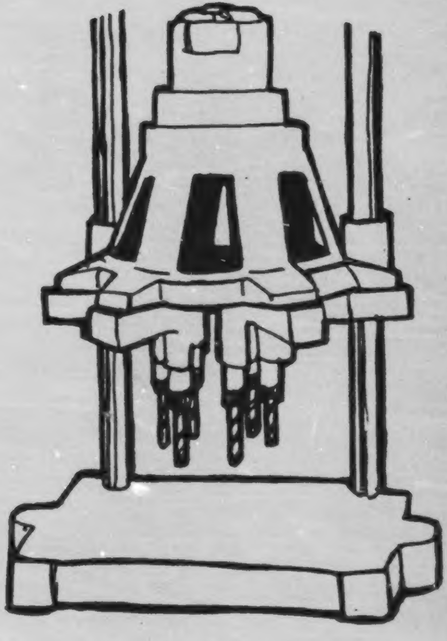
a. ______________________



b. ______________________



c. ______________________



d. ______________________

UNIT I

DRILLS AND DRILL PRESSES

ANSWERS TO TEST

Part 1

1. a. 5
   b. 4
   c. 1
   d. 3
   e. 2

2. a. bench model
   b. floor model

3. a. Speed adjustment handwheel
   b. Switch
   c. Depth gauge
   d. Spindle lock clamp
   e. Chuck
   f. Table
   g. Base
   h. Power assembly
   i. Feed wheel
   j. Table clamp lever
   k. Column

Part 2

1. a. 2
   b. 3
   c. 2
   d. 3
   e. 1
   f. 3
   g. 1
   h. 2

2. Answer should include three of the following five:
   a. To cool a drill during drilling so it will not lose its temper.
   b. To act as a lubricant to reduce friction at the cutting edge.
   c. To reduce the tendency of chips to weld to the cutting lips of the drill bit.
   d. To improve the finish of the hole.
   e. To wash away chips from the hole.

Part 3

1. a. Lip
   b. Flute
   c. Drill Body
   d. Shank
   e. Dead center
   f. Margin
   g. Body clearance
   h. Web
   i. Axis of drill
   j. Tang

2. a. C-clamp
   b. Step block
   c. T-slot bolt
   d. Vise
   e. V-block
   f. Strap clamp
   g. Angle plate
   h. Drill jig

Part 4

1. a. 5
   b. 1
   c. 3
   d. 4
   e. 2
   f. 7
   g. 6

2. a. Gang
   b. Radial
   c. Upright
   d. Multispindle

UNIT II

LATHE OPERATIONS

UNIT OBJECTIVE

After completion of this unit, the student will be able to identify the types of lathes, the parts of an engine lathe, and the accessories used on the engine lathe. The student will also be able to follow the correct safety procedures when performing the various operations performed on the lathe. This knowledge will be evidenced through demonstration and by satisfactorily completing the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student will be able to:

1. Explain the basic operation of the lathe.
2. Identify the types of lathes used in industry.
3. Identify the main parts of the lathe.
4. Select the correct safety rules to be followed when operating a lathe.
5. Identify the accessories available for a lathe headstock.
6. Identify the accessories used on the lathe carriage.
7. Identify the accessories used on a lathe tailstock.
8. Match the terms associated with the operation of a lathe to the correct definition.
9. Identify each of the operations performed on a lathe.
10. Point out the things to consider when setting feeds and speeds on the lathe.
11. Demonstrate the ability to:
    a. Figure Revolutions Per Minute (RPM)
    b. Figure taper per foot
    c. Figure tailstock offset
    d. Set up the lathe for turning in a chuck
    e. Set up the lathe for turning between centers
    f. Set up the lathe for turning on a mandrel
    g. Set up the lathe for turning a taper
    h. Set up the lathe for threading

i. Set up the lathe for drilling, reaming, and boring

j. Set up the lathe for parting

k. Set up the lathe for knurling

l. Set up the lathe for tool post grinding

m. File and polish on the lathe

n. Clean and lubricate the lathe

UNIT II

LATHE OPERATIONS

SUGGESTED TEACHING PROCEDURES

I. Objective sheet

   A. Discuss the unit objective with the students.

   B. Discuss each unit objective with the students.

   C. Have students complete the objectives in the most logical sequence for class organization.

   D. Add any objectives necessary.

II. Information and assignment sheets

   A. INFORMATION SHEET 1--INTRODUCTION TO LATHE OPERATIONS

      1. Discuss the types of lathes used in production shops. (Transparencies 1 and 2)

      2. Discuss the parts of the lathe (Transparencies 3-6)

      3. Discuss the safety factors relating to lathe operations (Transparencies 7 & 8)

   B. INFORMATION SHEET 2--ACCESSORIES

      1. Explain the use of the various headstock accessories. (Transparencies 9-11)

      2. Discuss the use of the various carriage accessories. (Transparencies 12-18)

      3. Explain the purpose of other lathe accessories (Transparency 19)

   C. INFORMATION SHEET 3--OPERATIONS

      1. Discuss the terms associated with various lathe operations.

      2. Explain the use or application of various lathe operations.

      3. Explain the difference in speeds and feeds. (Transparency 20)

      4. Use the following assignment sheets to reinforce this area of information:

         a. ASSIGNMENT SHEET 1--FIGURING RPM

         b. ASSIGNMENT SHEET 2--FIGURE TAPER PER FOOT

         c. ASSIGNMENT SHEET 3--FIGURE TAILSTOCK OFFSET

III. Transparency masters

A. TM-1--TYPES OF LATHES

B. TM-2--MODIFIED LATHES

C. TM-3--TYPES OF HEADSTOCK DRIVES

D. TM-4--THE LATHE HEADSTOCK

E. TM-5--PARTS OF THE CARRIAGE

F. TM-6--PARTS OF THE TAILSTOCK

G. TM-7--SAFETY FIRST

H. TM-8--SAFETY EQUIPMENT

I. TM-9--TYPES OF CHUCKS

J. TM-10--TYPES OF SPINDLES

K. TM-11--OTHER HEADSTOCK ACCESSORIES

L. TM-12--TYPES OF TOOL POSTS

M. TM-13--TOOL HOLDERS

N. TM-14--TYPES OF BORING BARS

O. TM-15--TOOL STEEL CUTTING TOOLS

P. TM-16--CARBIDE CUTTING TOOLS

Q. TM-17--CARBIDE TOOL FORMS

R. TM-18--OTHER CARRIAGE ACCESSORIES

S. TM-19--OTHER LATHE ACCESSORIES

T. TM-20--CUTTING SPEEDS FOR TURNING DIFFERENT MATERIALS

IV. Job sheets

A. JOB SHEET 1--SET UP FOR TURNING IN A CHUCK

B. JOB SHEET 2--SETUP FOR TURNING BETWEEN CENTERS

C. JOB SHEET 3--SETUP FOR TURNING ON A MANDREL

D. JOB SHEET 4--SETUP FOR TURNING A TAPER

E. JOB SHEET 5--SETUP FOR THREADING

F. JOB SHEET 6--SETUP FOR DRILLING, REAMING, AND BORING

G. JOB SHEET 7--SETUP FOR PARTING

H. JOB SHEET 8--SETUP FOR KNURLING

I. JOB SHEET 9--SETUP FOR TOOL POST GRINDING

J. JOB SHEET 10--FILING AND POLISHING

K. JOB SHEET 11--CLEANING AND LUBRICATING THE LATHE

V. Answers to assignments

A. Show the students how to figure any problems missed.

B. Provide additional problems for areas missed on assignments.

VI. Unit test

A. The unit test is divided into three parts.

(NOTE: Each part covers one information sheet.)

B. Various approaches may be used in testing.

1. Each part of the test may be given as the student reviews the information on each information sheet.

2. Give the entire test upon completion of all the information sheets in the unit.

3. Give one or more parts of the test as an additional assignment, or to reinforce areas the students did not understand.

C. Add test parts corresponding to any information area or sheets added to the unit.

VII. Answers to the test

A. Answers are based on total information provided in the unit.

B. For convenience of grading, add corresponding answer sheets for additional test parts.

VIII. References

A. Walker, John R. Machining Fundamentals. The Goodheart-Wilcox Co., Inc., South Holland, Illinois, 1969.

B. Burghardt, Axelrod, Anderson. Machine Tool Operation, Part 1, McGraw-Hill Book Co., Inc. New York, 1959.

C. McCarthy, Willard J. & Smith, Robert E. Machine Tool Technology. McKnight & McKnight Publishing Co. Bloomington, Illinois, 1968.

D. Walker, John R. Modern Metalworking. The Goodheart-Wilcox Co., Inc. South Holland, Illinois, 1976.

E. A Suggested Basic Course Outline for General Metal Trades Cluster. Occupational Curriculum Laboratory, East Texas State University, Commerce, Texas 75428.

UNIT II

LATHE OPERATIONS

INFORMATION SHEET 1--INTRODUCTION TO LATHE OPERATIONS

I. The engine lathe

   A. The engine lathe is a power-driven machine tool which removes metal from a workpiece by rotating the workpiece against a single-point cutting tool.

   B. The engine lathe is capable of performing any operation needed to machine any replacement part on the lathe.

II. Types of lathes (Transparency 1 and 2)

   A. Engine lathe (Transparency 3)

      1. Drives

         a. Belt-driven

         b. Gear head-driven

      2. Designs

         a. Gap lathe

         b. Bench lathe

         c. Tool room

   B. Turret lathe

      (NOTE: Turret attachments can be placed on a regular engine lathe.)

      1. Horizontal

         (NOTE: Horizontal turret lathes will have either a ram or saddle type turret.)

      2. Vertical

   C. Numerical control (NC) lathe

      1. A programmed lathe used to perform a number of operations on the workpiece without the machine operator's assistance.

      2. Holds close tolerances even with rapid output of parts.

   D. Automatic lathes--Used where rapid production of easily machined parts and little operator assistance is required.

      1. Single-spindle

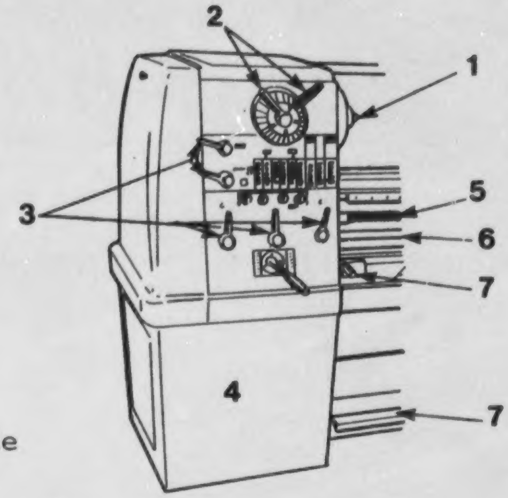
      2. Multiple-spindle

E. Tracer lathe--Used when parts can be duplicated from a master part with simple operations of the lathe.

III. Parts of the lathe

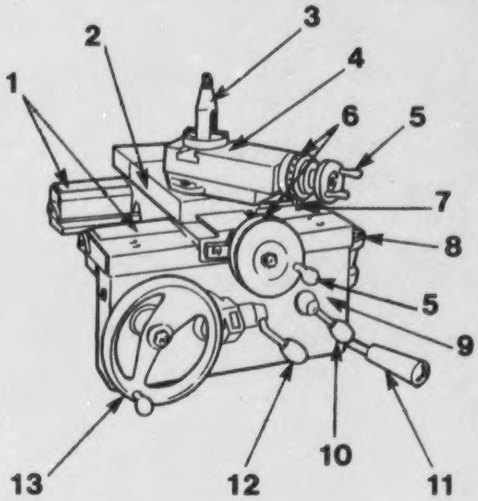
A. Headstock (Transparency 4)

1. Spindle
2. Speed-change levers
3. Feed-change levers
4. Motor
5. Lead screw
6. Feed rod
7. Spindle clutch and brake



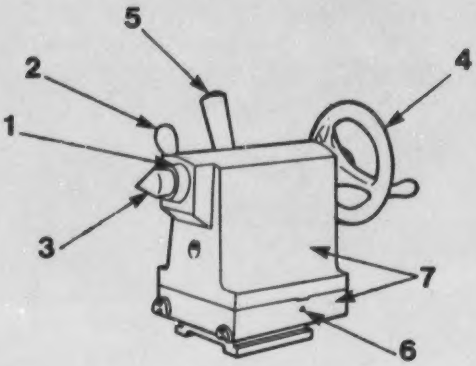
B. Carriage (Transparency 5)

1. Saddle
2. Cross slide
3. Tool post
4. Compound rest
5. Cross-feed cranks
6. Micrometer collars
7. Carriage lock
8. Thread chasing dial
9. Apron
10. Half-nut lever
11. Clutch and brake
12. Power-feed lever
13. Carriage handwheel



C. Tailstock (Transparency 6)

1. Ram
2. Ram lock lever
3. Dead center
4. Handwheel
5. Tailstock lock lever
6. Offset screws
7. Housing



IV. Safety (Transparency 7 and 8)

A. Wear protective clothing

1. Eye protection

   (NOTE: Select from glasses, goggles or face shields for your own comfort.)

2. Ear protection
3. Snug-fitting clothes
4. Short sleeves or rolled-up long sleeves
5. Long hair contained with a cap or tied back
6. A protective apron or coveralls

   (NOTE: Remove rings, watches, or other jewelry before operating a lathe.)

B. Operate a lathe only after you have received proper instructions.

1. Always get permission from the instructor before operating the lathe.
2. Allow only one operator to control the lathe.

C. Stop the lathe before making adjustments or removing chips.

1. Remove chips with a brush.
2. Never wipe moving parts with a rag.
3. Do not shift gears while the lathe is running.
4. Stop the lathe before attempting to measure parts.
5. Keep hands and fingers away from moving parts.

D. Handle tools and accessories properly and do not lay them on the bed, ways, or saddle.

  1. Get help when lifting heavy chucks or accessories.
  2. Use a board or wood block to protect the ways when installing a chuck.
  3. Remove the chuck wrench from the chuck after adjusting the jaws of the chuck.
  4. Be careful with sharp or pointed tools.
  5. Keep handles on files and deburring tools.
  6. Stand to one side when filing.

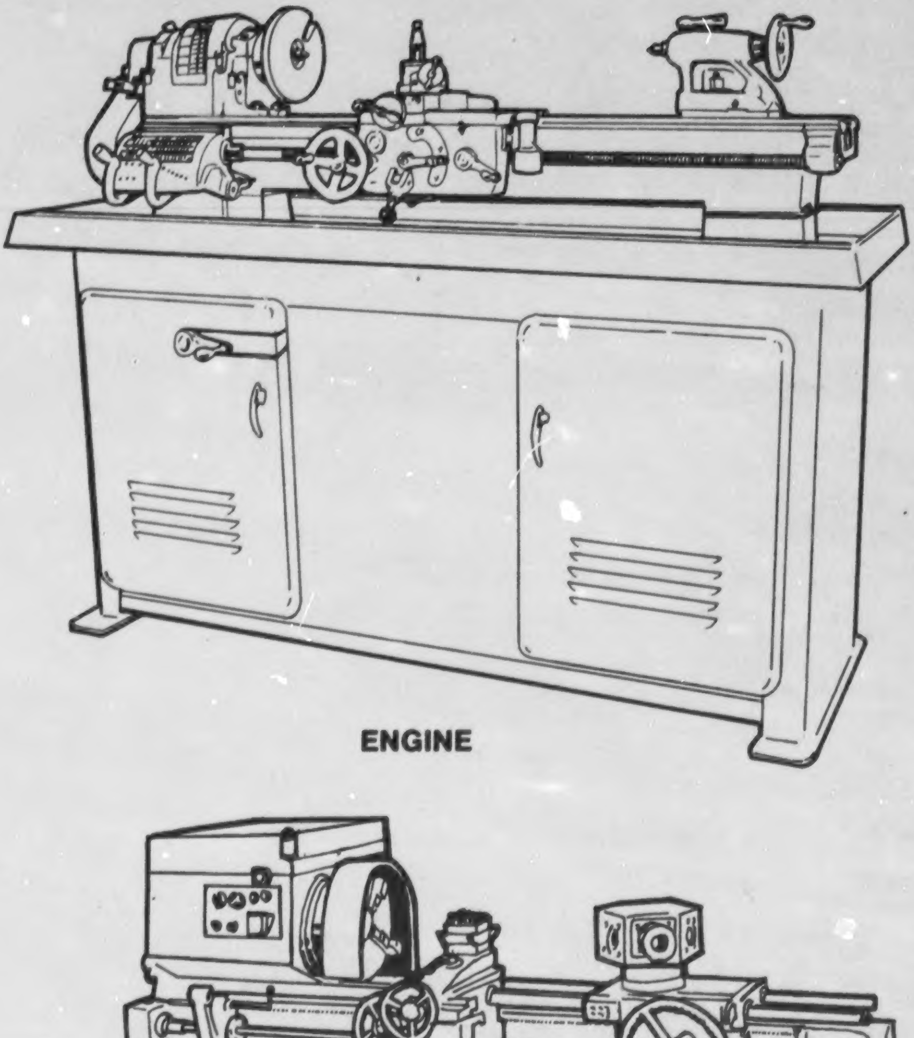
E. Use the lathe correctly and provide proper maintenance.

  1. Keep all guards in place.
  2. Report all needed repairs to the instructor.
  3. Do not operate a lathe with faulty parts.
  4. Clean up spilled oil or coolant immediately.
  5. Check the chuck and workpiece for clearance by hand before turning on the power.

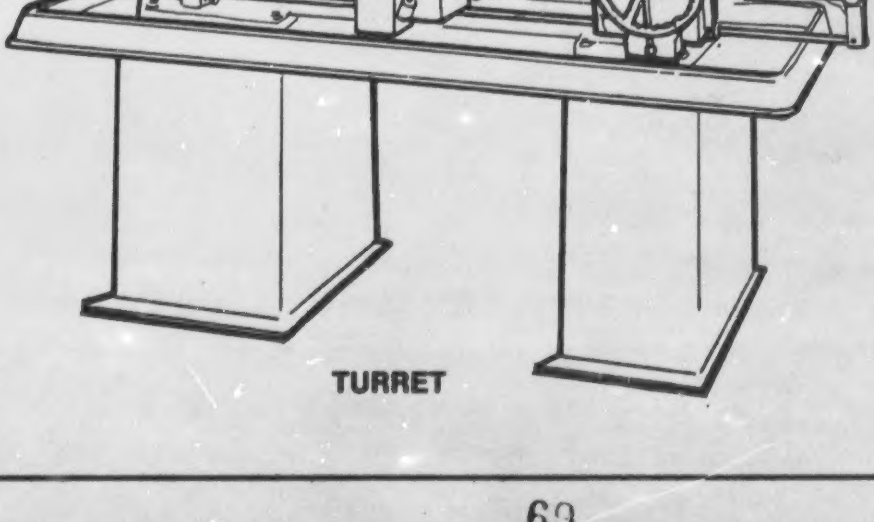
F. Do not allow horseplay around the lathe.

  1. Stand erect, keep alert, and do not lean on the lathe.
  2. Never leave a lathe unattended.
  3. Do not talk to another lathe operator while the lathe is running.
  4. Do not play with compressed air.

TYPES OF LATHES



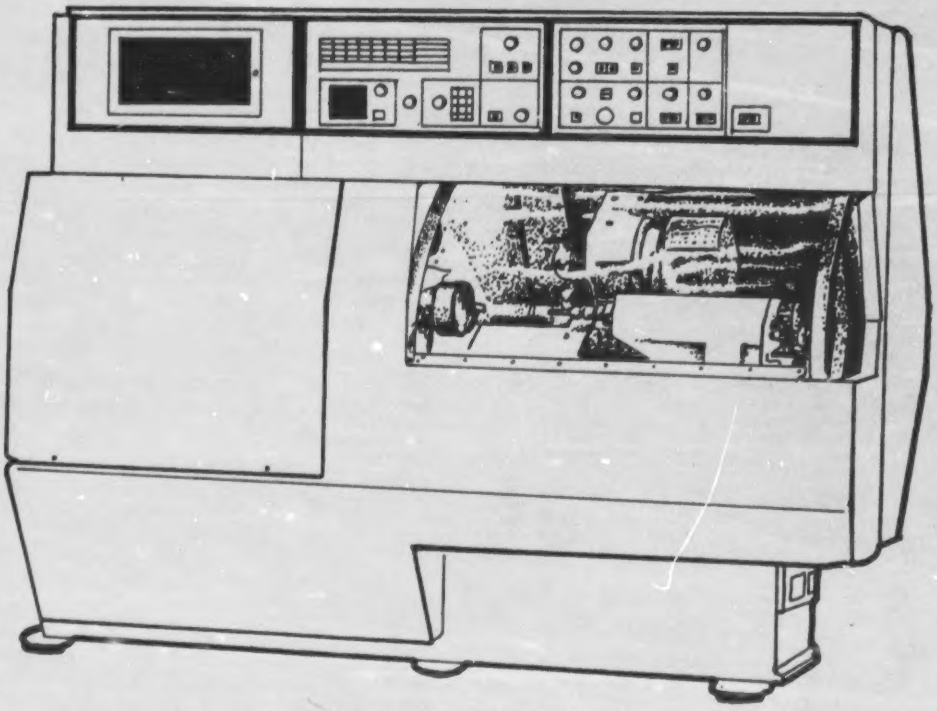
ENGINE



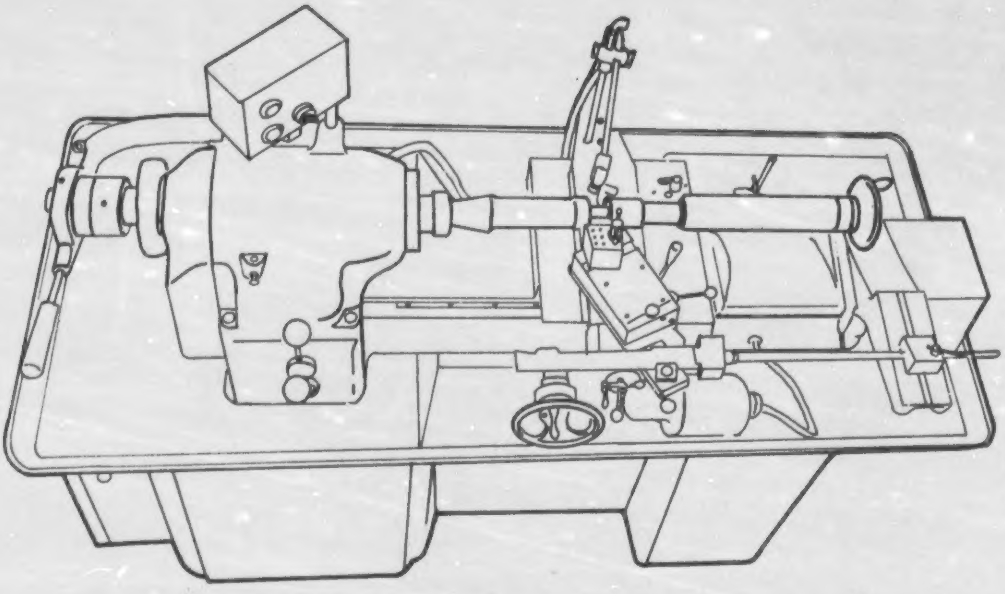
TURRET

TM-1

MODIFIED LATHES

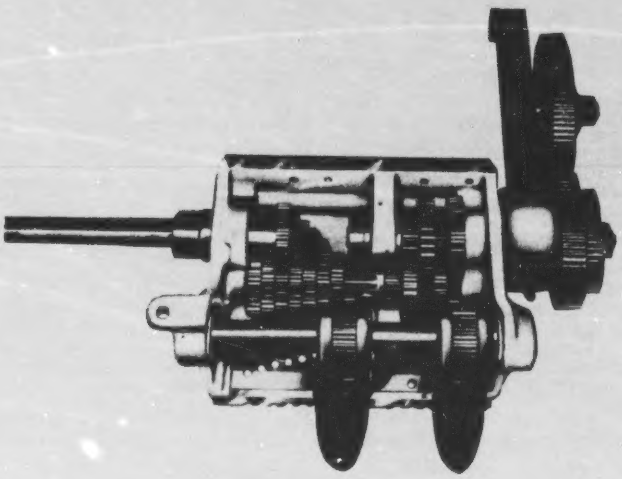


NUMERICAL CONTROL

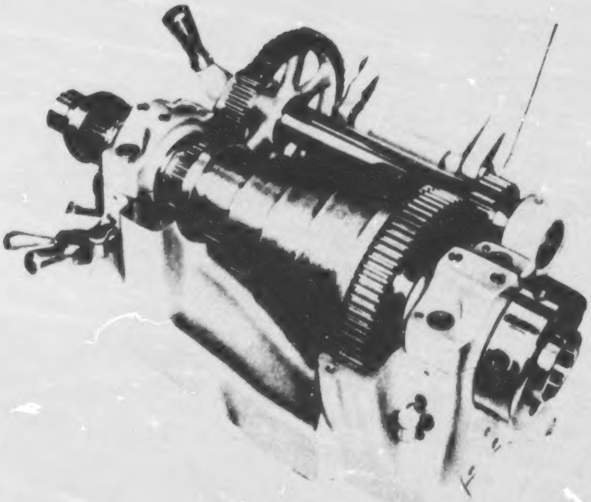


TRACER

TYPES OF HEADSTOCK DRIVES

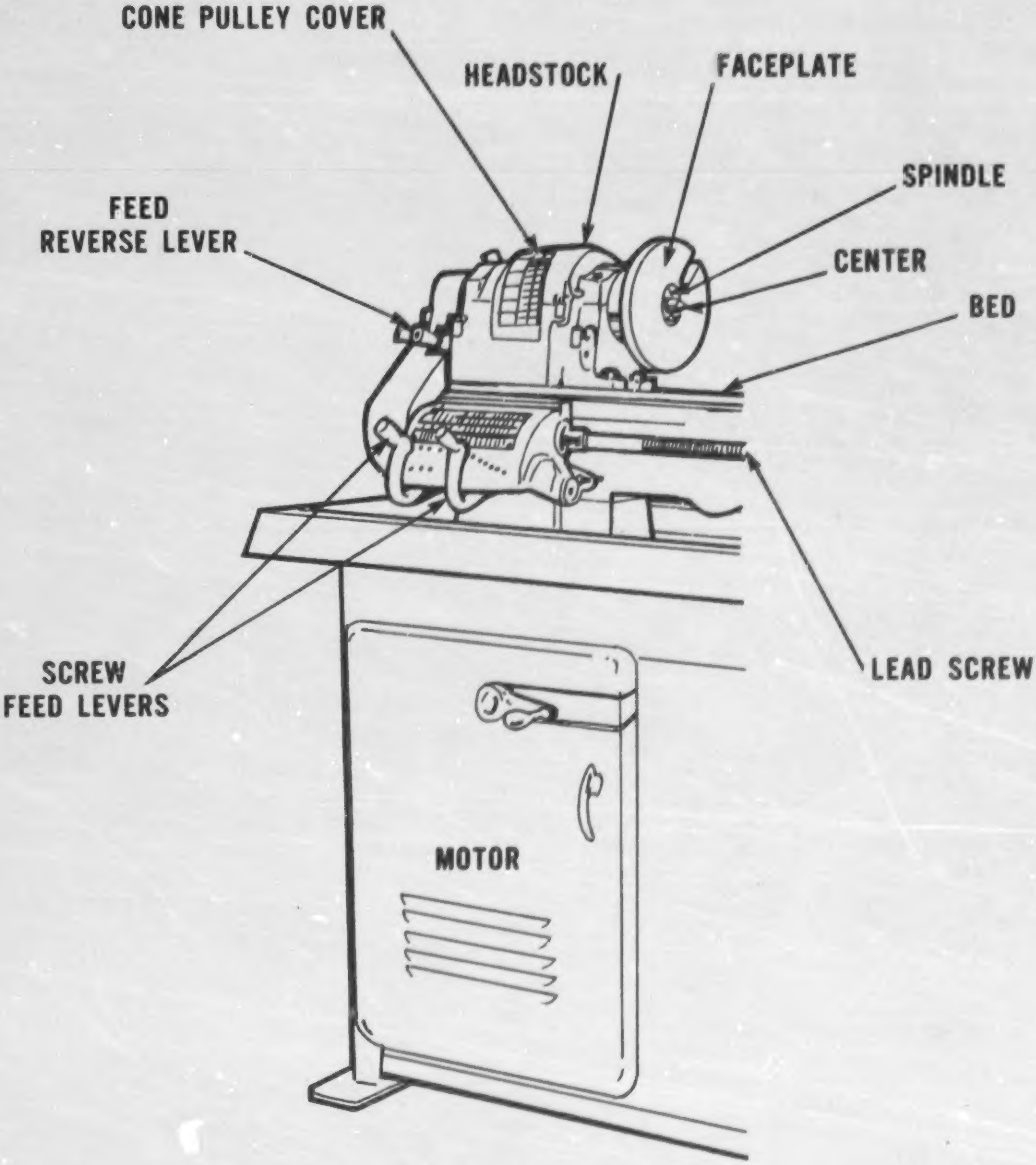


GEAR TYPE

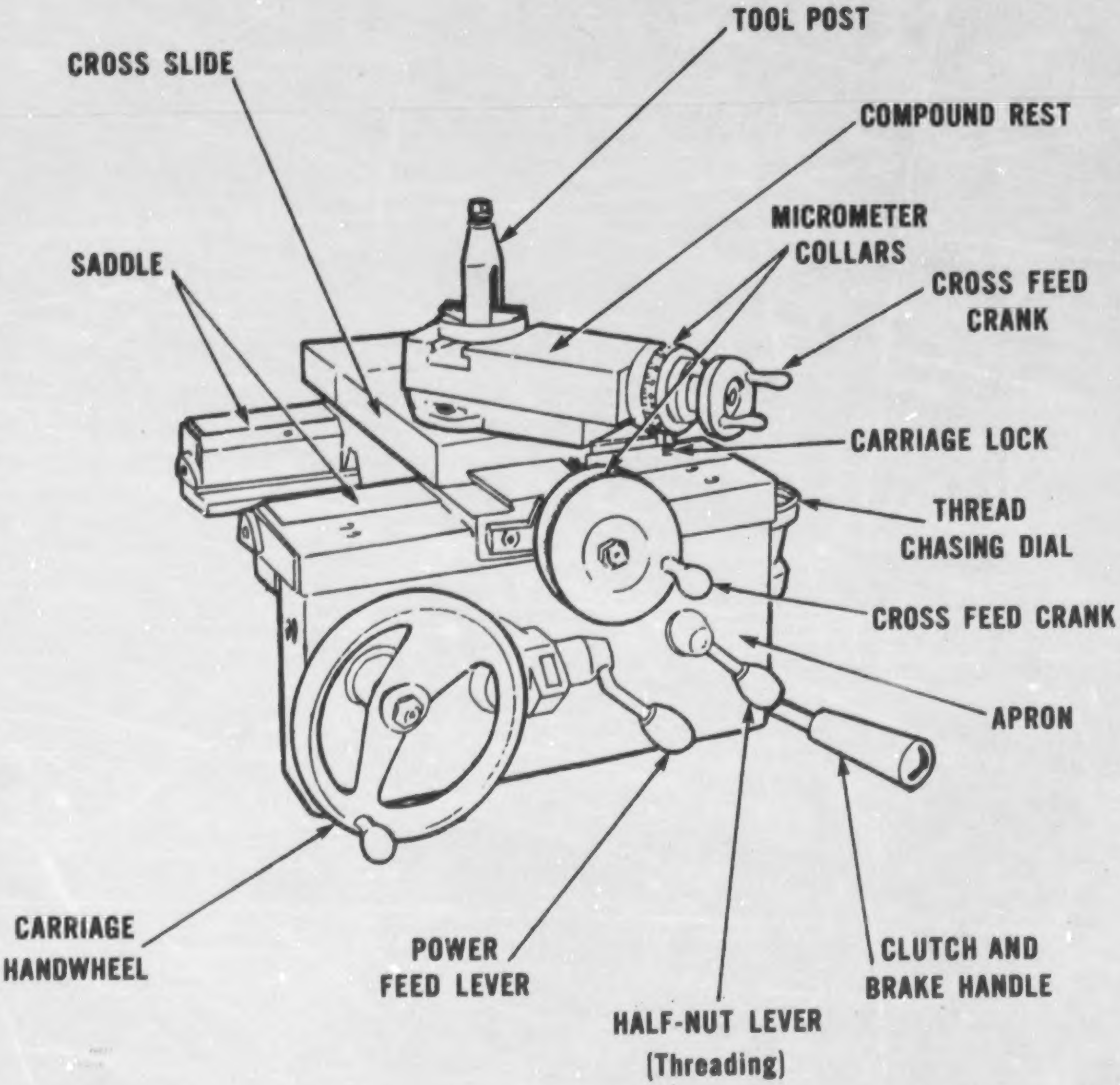


CONE PULLEY

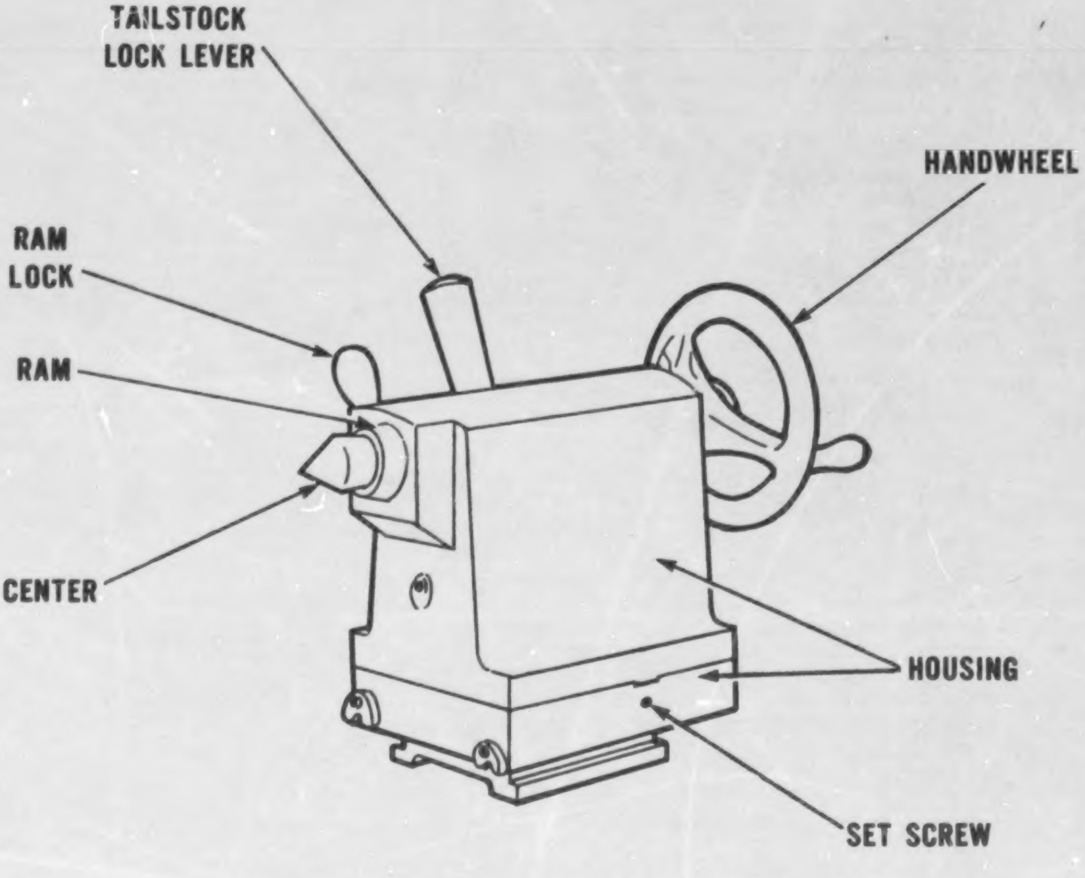
THE LATHE HEADSTOCK


CONE PULLEY COVER
HEADSTOCK
FACEPLATE
SPINDLE
FEED REVERSE LEVER
CENTER
BED
LEAD SCREW
SCREW FEED LEVERS
MOTOR

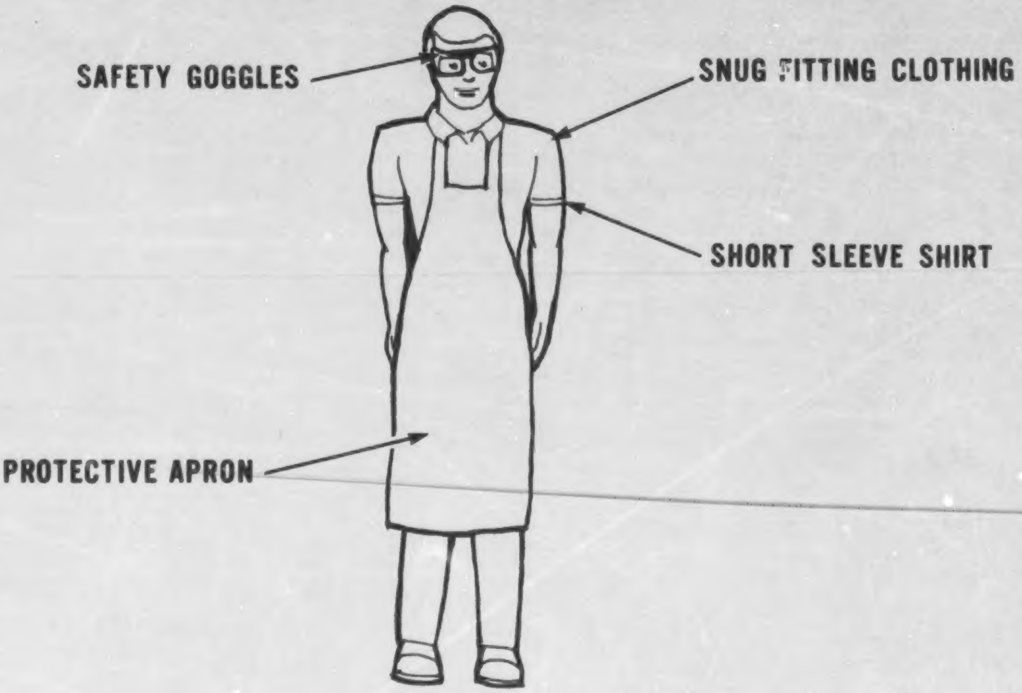
PARTS OF THE CARRIAGE


TOOL POST
CROSS SLIDE
COMPOUND REST
MICROMETER COLLARS
SADDLE
CROSS FEED CRANK
CARRIAGE LOCK
THREAD CHASING DIAL
CROSS FEED CRANK
APRON
CARRIAGE HANDWHEEL
POWER FEED LEVER
CLUTCH AND BRAKE HANDLE
HALF-NUT LEVER (Threading)

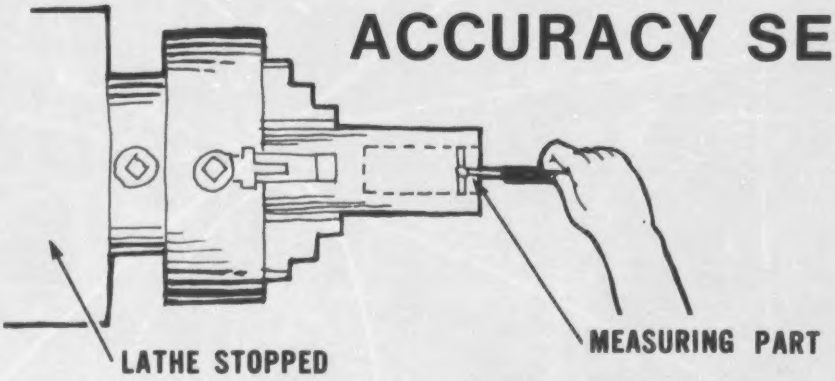
PARTS OF THE TAILSTOCK


TAILSTOCK LOCK LEVER
HANDWHEEL
RAM LOCK
RAM
CENTER
HOUSING
SET SCREW

SAFETY FIRST

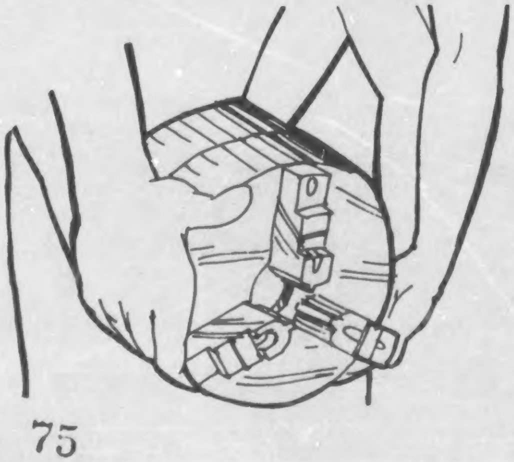

SAFETY GOGGLES
SNUG FITTING CLOTHING
SHORT SLEEVE SHIRT
PROTECTIVE APRON

ACCURACY SECOND

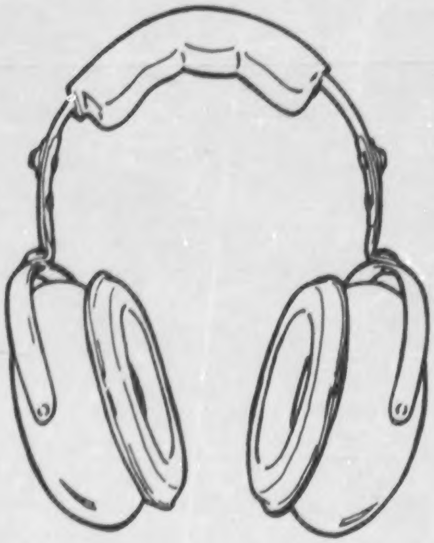

LATHE STOPPED
MEASURING PART

SPEED LAST

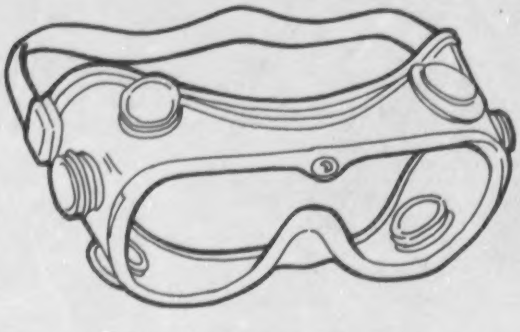
DON'T LIFT OR CARRY
HEAVY PARTS ALONE



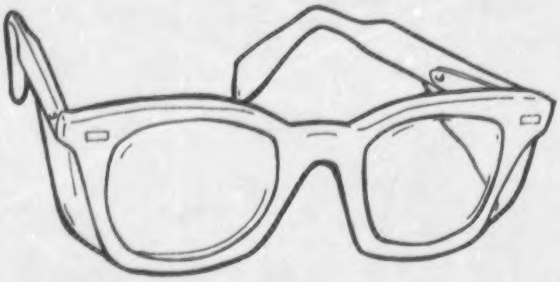
SAFETY EQUIPMENT



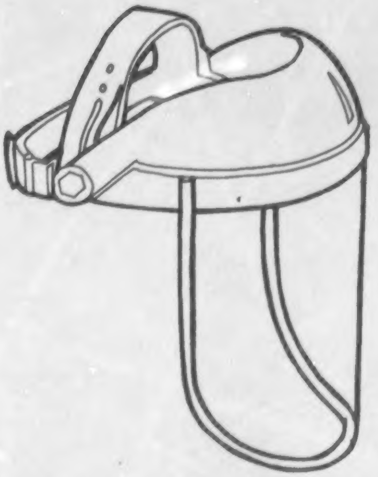
EAR PROTECTORS



SAFETY GOGGLES



SAFETY GLASSES



FACE SHIELD

UNIT II

LATHE OPERATIONS

INFORMATION SHEET 2--ACCESSORIES

I. Headstock accessories

   A. Lathe chucks

      1. Three-jaw universal--All three jaws of the chuck move together so that the workpiece will be centered without aligning.

      2. Four-jaw independent--A chuck with jaws that move separately so that the workpiece must be aligned.

         (NOTE: This chuck is also used to align irregular shaped workpieces.)

      3. Six-jaw combination--A chuck designed to provide a strong grip on the workpiece.

      4. Two-jaw universal--A chuck designed to hold workpieces during very simple operations such as polishing of filing.

   B. Spindles

      (NOTE: Chucks and faceplates are designed to fit the following spindles.)

      1. Threaded

      2. Cam-lock

      3. Tapered spindle with key drive.

   C. Faceplates--A round plate that is placed on the spindle to provide a flat surface for mounting workpieces.

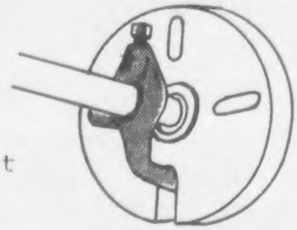
      (NOTE: When used for turning between centers they are called drive plates.)

   D. Collets--A chucking device which can quickly clamp against the workpiece as it is pushed through the hollow spindle of the lathe.

      (NOTE: Collets are designed to be used with different sizes and shapes of stock, such as round or hexagon bar stock.)

   E. Lathe dogs--The clamp used to drive the workpiece when turning between centers.

      (NOTE: The lathe dogs come in different sizes and shapes and fit into the drive plate slots.)



II. Carriage accessories

- A. Tool posts--These hold different tools or tool holders.
    - 1. Rocker
    - 2. Open side or blocks
    - 3. Four-way
    - 4. Quick-change
- B. Tool holders--These hold various-shaped cutting tools for different operations.
    - 1. Right-hand offset
    - 2. Left-hand offset
    - 3. Straight

      (NOTE: The above three tool holders are sized for square tool steel bits from 1/4 inch to 3/8 inch square.)
    - 4. Adjustable--Can be used with different sizes of tool steel bits.
    - 5. Parting--Holds blade like tool steel cutters.
    - 6. Threading--Holds a single-point bit used for threading.
    - 7. Boring bar--Holds bars (usually round) which are used to remove metal from inside the workpiece.
    - 8. Knurling--Available with one or more sets of rollers that have different patterns of grooves.
- C. Boring bars--These can be designed for internal operations similar to external operations.
    - 1. Light duty
    - 2. Medium duty
    - 3. Heavy duty
- D. Cutting tools
    - 1. Tool steel--Can be ground in any shape such as job right or left hand turning.
    - 2. Carbide--These cutting tools have formed carbide tips soldered or inserted on tool forms for the specific operation.

E. Taper attachment--Guides the cutting tool and carriage when a taper is machined.

F. Tool post grinder--Used to grind hardened round workpieces on the lathe.

G. Follower-rest--Attached to the carriage to support long workpieces when they push away from the cutting tool.

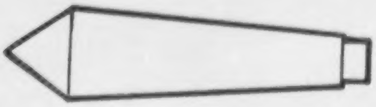
III. Tailstock accessories

A. Centers--Cone-shaped points which provide a center line and support for the workpiece.

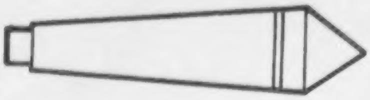
(NOTE: Dead centers can also be used in the spindle to support the end of the workpiece as it is driven by the lathe dog.)

1. Solid

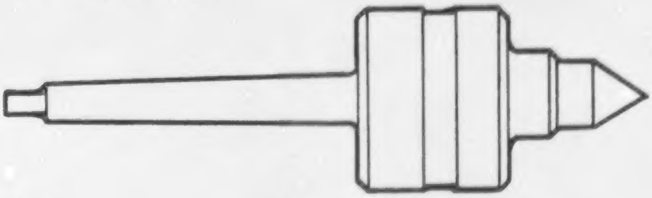
   a. Live--Means that it rotates with the spindle.



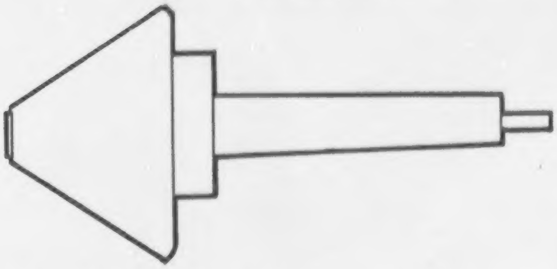
   b. Dead--Means that it does not move.



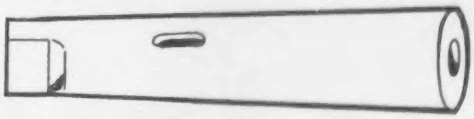
2. Ball bearing



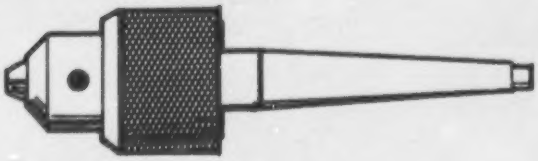
3. Pipe



B. Sleeves--Hollow tapered devices used to adapt tapered shank cutting tools to be tapered tail stock (or redstock) spindle.



C. Drill chuck--Inserted in the tailstock to hold center drills or straight shank cutting tools (drills etc.) while the stock rotates.



IV. Other lathe accessories

A. Steady rest--A support for long workpieces being turned without the tailstock for support.

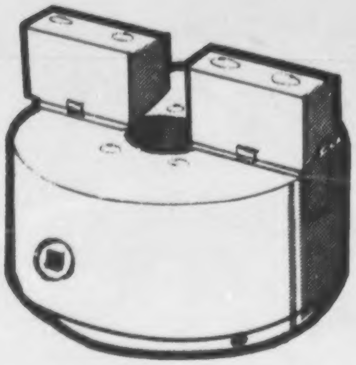
(NOTE: The guides in the steady rest will be roller bearings or brass bars.)

B. Carriage stop--A device that attaches to the bed of the lathe to stop the travel of the carriage at the specified point.

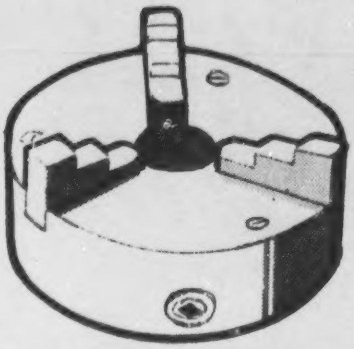
C. Mandrel--A slightly tapered steel shaft that supports work that cannot be held by any other method for machining between centers.

(NOTE: This allows the surfaces of the workpiece to be machined without having to turn the part around in in a chuck.)

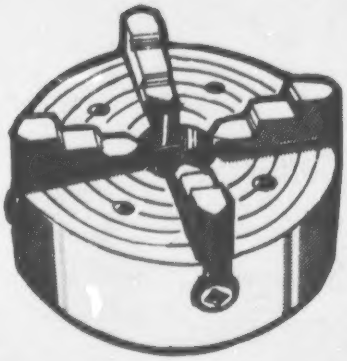
TYPES OF CHUCKS



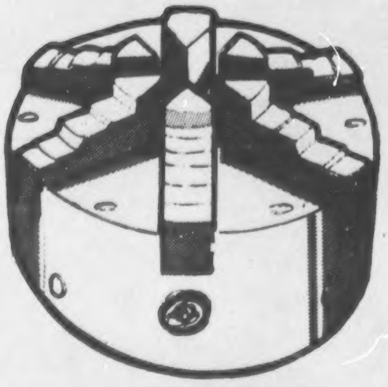
TWO-JAW UNIVERSAL



THREE-JAW UNIVERSAL

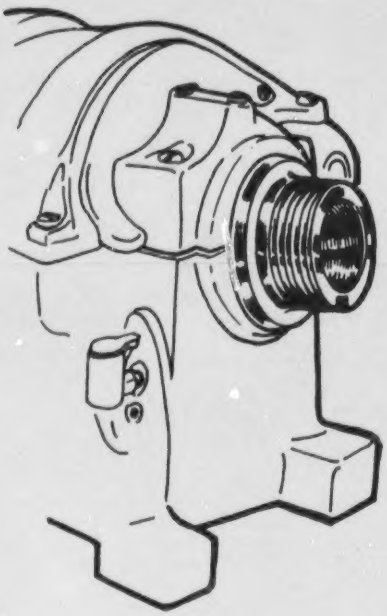


FOUR-JAW INDEPENDENT



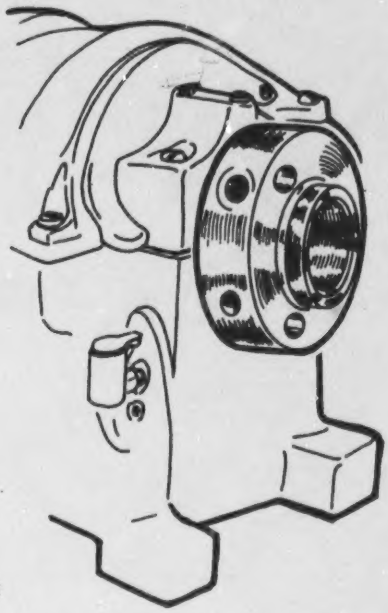
SIX-JAW COMBINATION

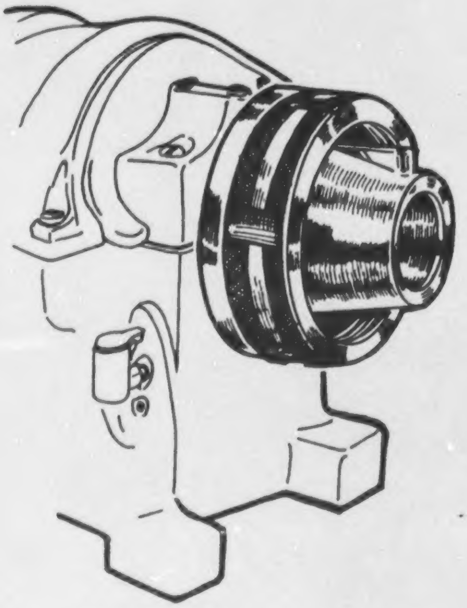
TYPES OF SPINDLES



THREADED

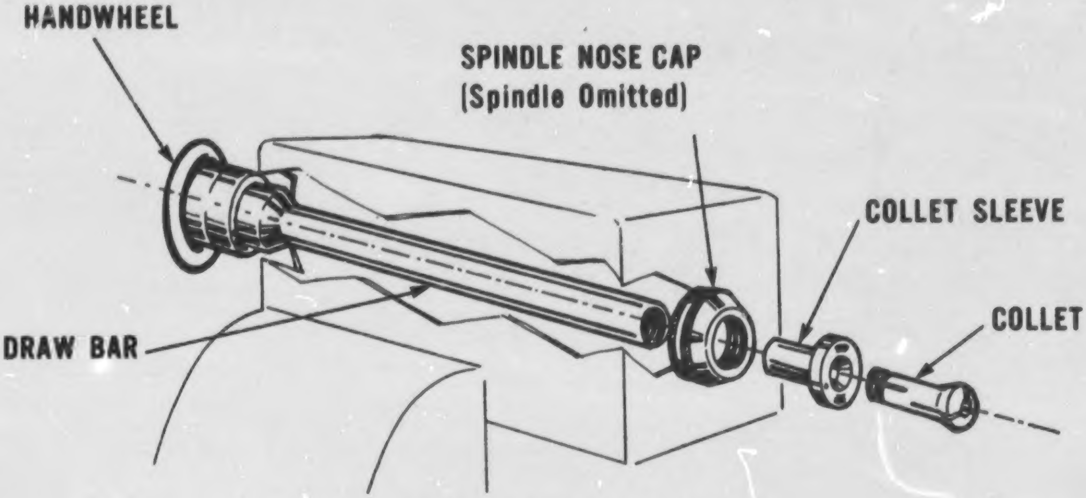
CAM-LOCK



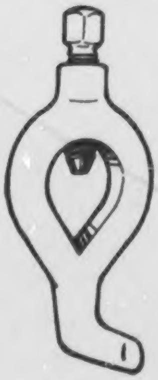


LONG TAPER KEY

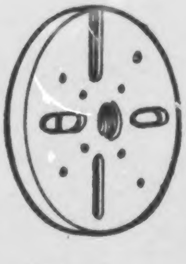
OTHER HEADSTOCK ACCESSORIES


HANDWHEEL
SPINDLE NOSE CAP
(Spindle Omitted)
COLLET SLEEVE
COLLET
DRAW BAR

DRAW-IN COLLET CHUCK

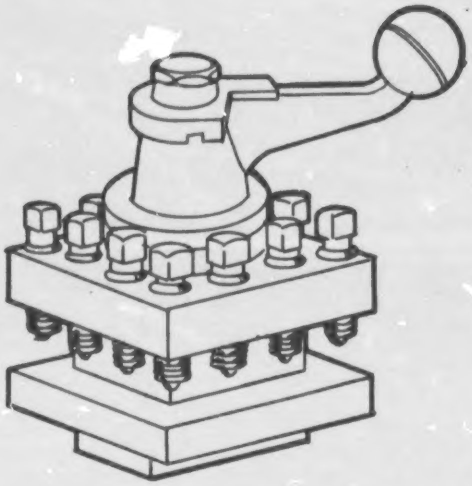


BENT TAIL
LATHE DOG

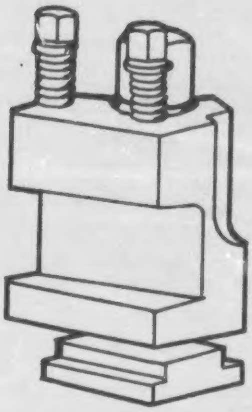


FACEPLATE

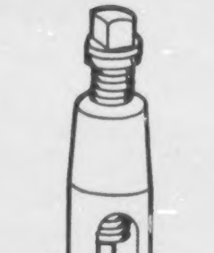
TYPES OF TOOL POSTS



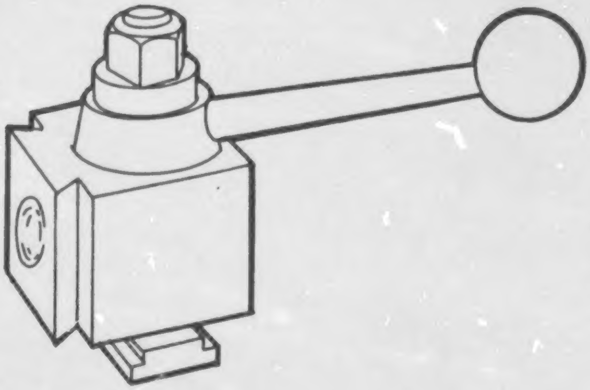
4-WAY



OPEN SIDE

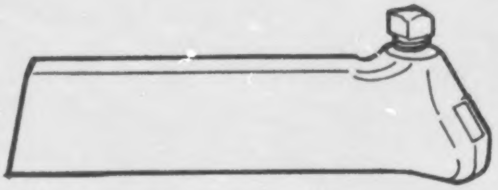


ROCKER

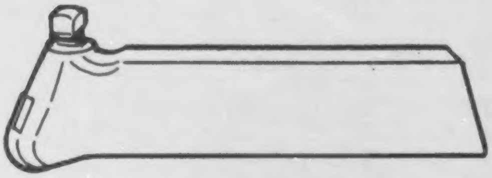


QUICK CHANGE

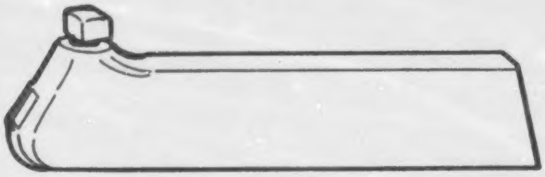
TOOL HOLDERS



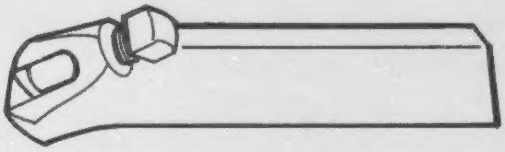
LEFT-HAND



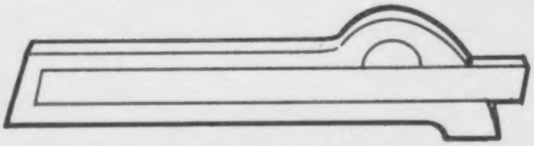
RIGHT-HAND



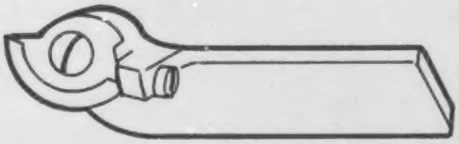
STRAIGHT



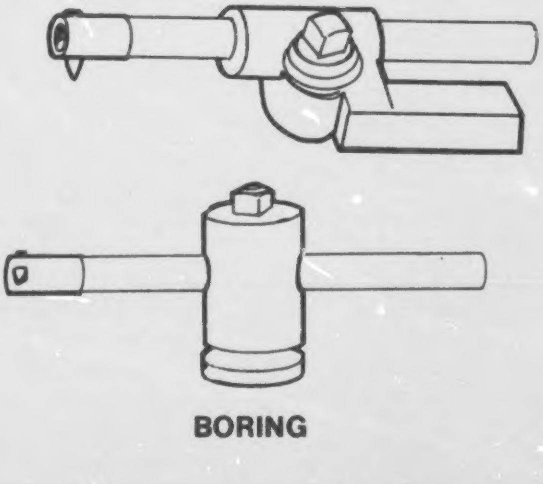
ADJUSTABLE



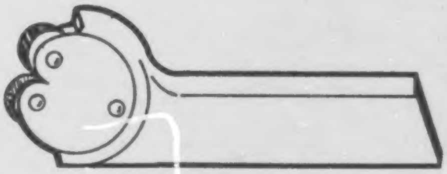
PARTING



THREADING



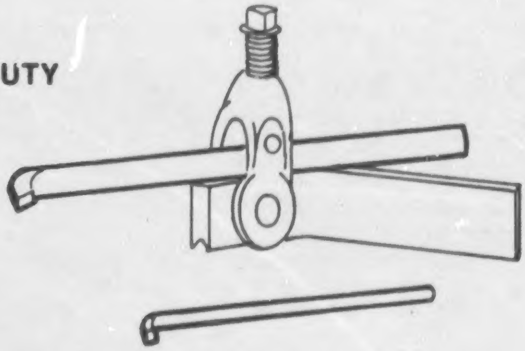
BORING

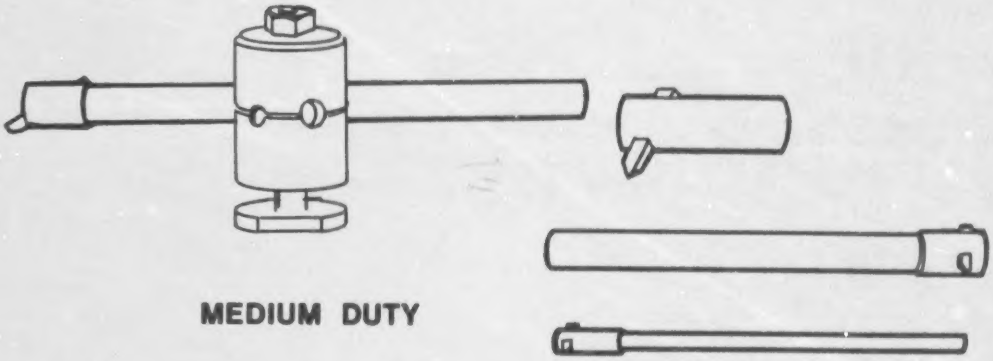


KNURLING

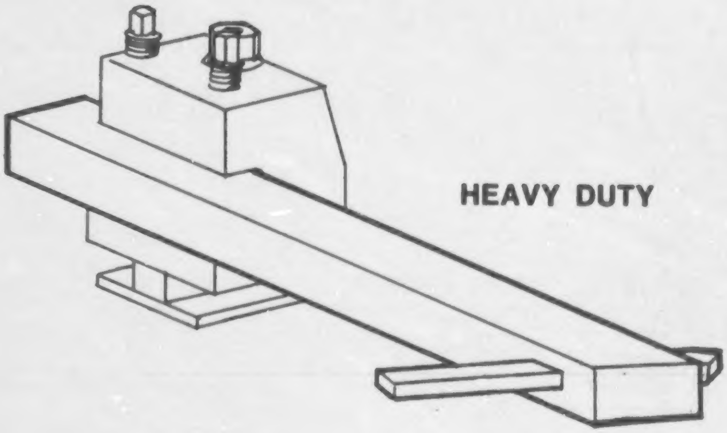
TYPES OF BORING BARS

LIGHT DUTY



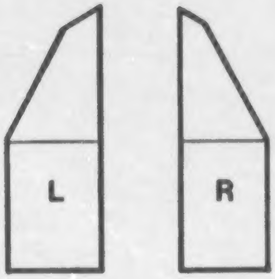


MEDIUM DUTY

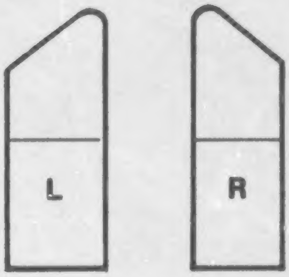


HEAVY DUTY

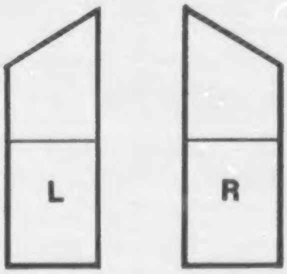
TOOL STEEL CUTTING TOOLS



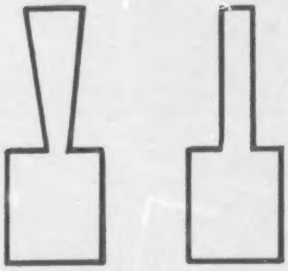
FACING



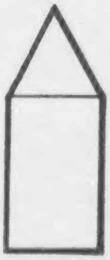
ROUGHING



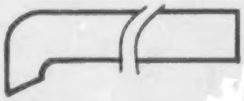
FINISHING



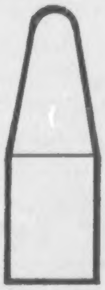
PARTING
OR CUTOFF



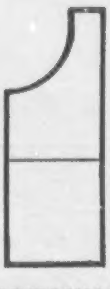
THREADING



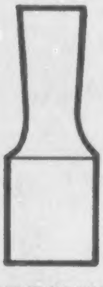
BORING



ROUNDNOSE

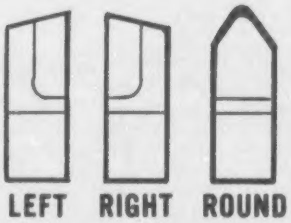


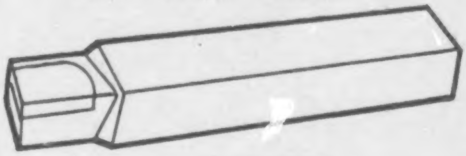
FORMING



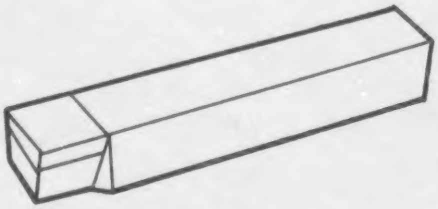
NECKING

CARBIDE CUTTING TOOLS

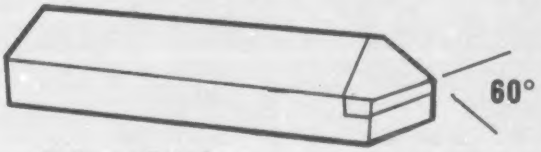

LEFT
RIGHT
ROUND



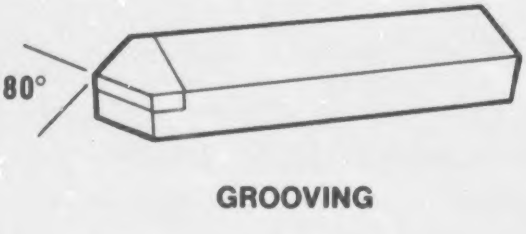
TURNING



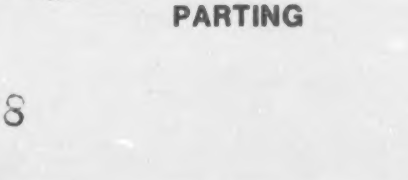
SQUARE NOSE



THREADING

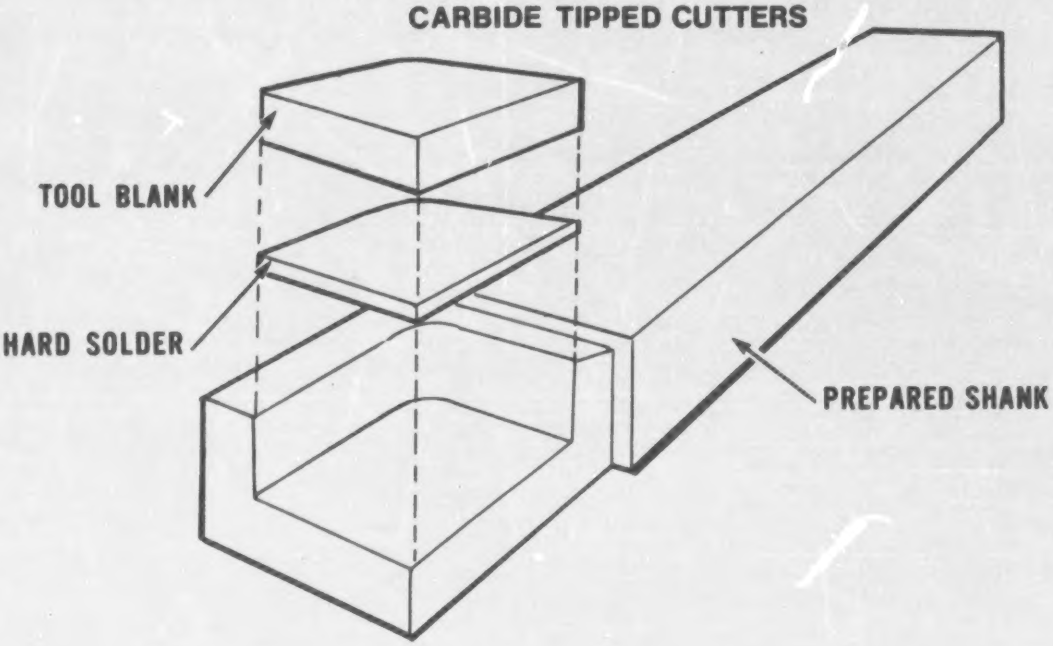


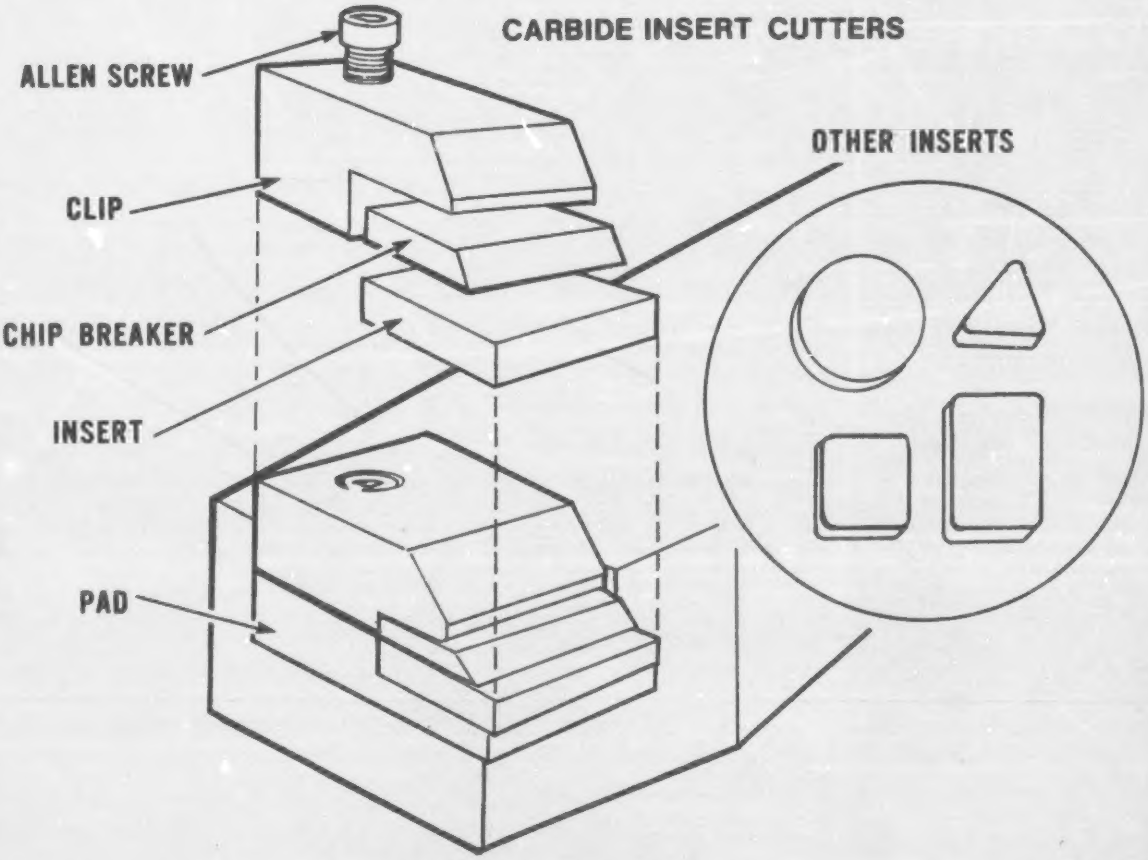
GROOVING



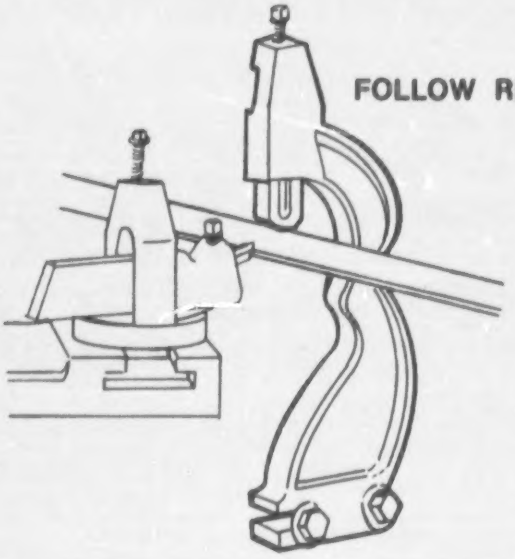
PARTING

CARBIDE TOOL FORMS

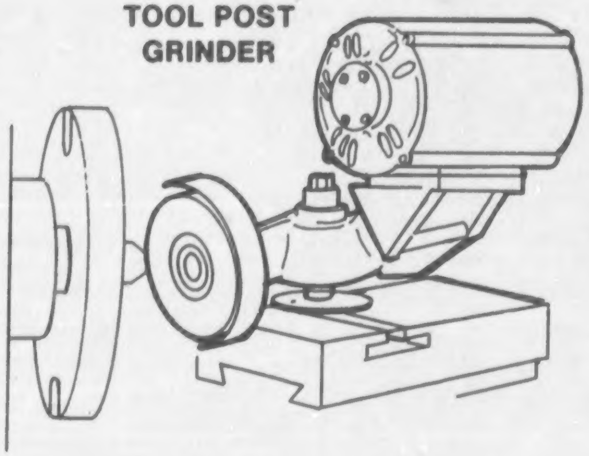

CARBIDE TIPPED CUTTERS
TOOL BLANK
HARD SOLDER
PREPARED SHANK


CARBIDE INSERT CUTTERS
ALLEN SCREW
CLIP
CHIP BREAKER
INSERT
PAD
OTHER INSERTS

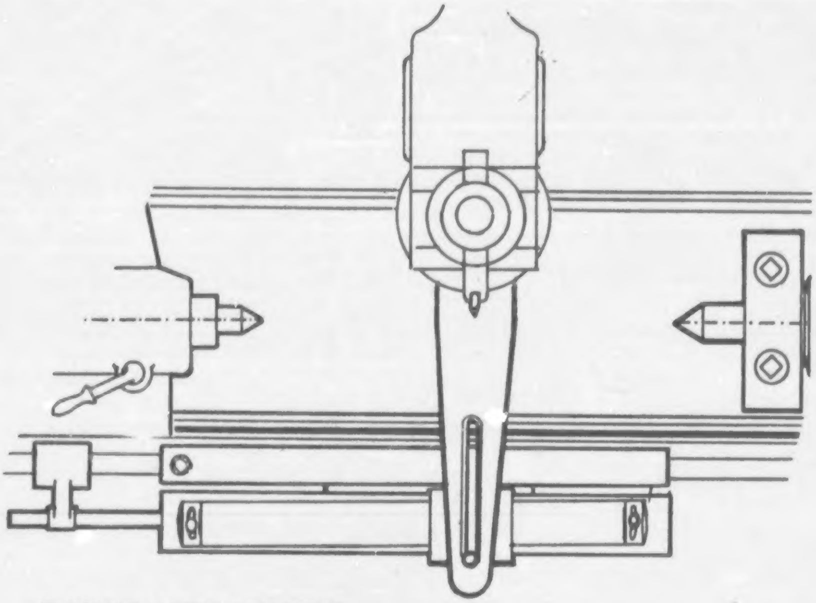
OTHER CARRIAGE ACCESSORIES



FOLLOW REST

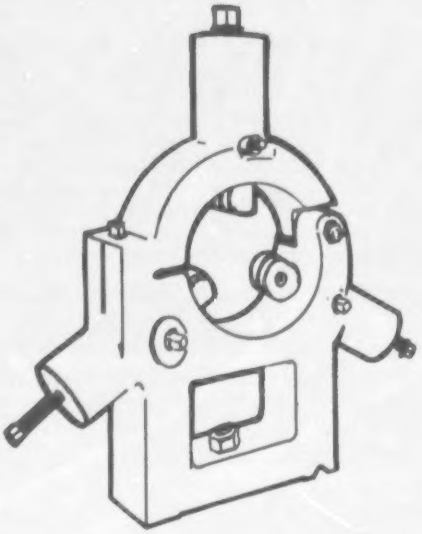


TOOL POST GRINDER

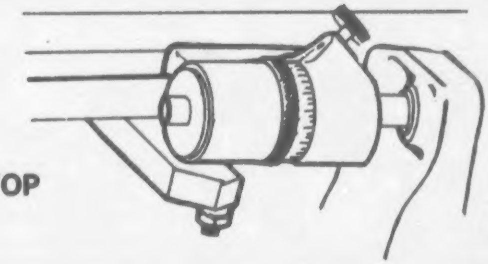


TAPER ATTACHMENT

OTHER LATHE ACCESSORIES

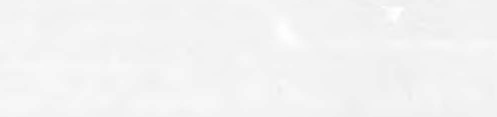


STEADY REST



CARRIAGE STOP

MANDREL



CUTTING SPEEDS FOR TURNING DIFFERENT MATERIALS

MATERIAL	SUGGESTED CUTTING SPEEDS sfpm*
Free-machining steel	160-350
Low-carbon steel (.05%-.30%)	90-100
Medium-carbon steel (.30%-.60%)	70-90
High-carbon tool steel (.60-1.70%)	50-70
Tough alloy steel	50-70
Stainless steel	40-70
Stainless steel, free-machining	80-140
Cast iron, soft	50-80
Cast iron, hard	30-50
Cast iron, malleable	80-100
Aluminum	200-1500
Copper	100-120
Brass	150-300
Bronze	90-100
Molded plastics	150-300
Plastics, acrylic	60-70
Fiber	80-100

*Use the lower speeds on roughing cuts and when machining dry. Use higher speeds when using cutting fluids and on finishing cuts.

UNIT II

LATHE OPERATIONS

INFORMATION SHEET 3--OPERATIONS

I. Terms and definitions

A. Centering--Aligning a workpiece on center line of the spindle of the lathe.

(NOTE: There are many methods of centering the workpiece, but the dial indicator is usually used when centering stock in the four-jaw chuck.)

B. Cutting speed (CS)--The speed of the outside edge of the workpiece which is stated in feet per minute (FPM).

C. Depth of cut--The amount of stock removed in one pass of the cutting tool.

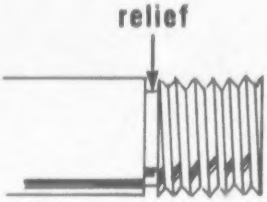
D. Feed--The distance the tool moves with each revolution of the workpiece.

E. Material--The type of metal the workpiece is made of.

F. Pressfit--When the sizes of two parts are so close that they must have force applied for them to fit together.

G. Relief--A small groove cut around metal with a parting tool.

(NOTE: The relief cut provides a stopping spot for threads or machining operation.)



H. Revolutions per minute (RPM)--The number of times the workpiece rotates in one minute.

I. Specified--The size called for on a blueprint.

J. Taper per foot--The difference in diameters for one foot in length of a coned shaped part.

(NOTE: Taper per inch is also used to show taper sizes.)

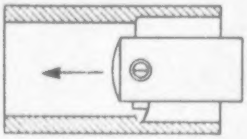
K. Tool steel--A hard metal used to make cutting tools for the lathe.

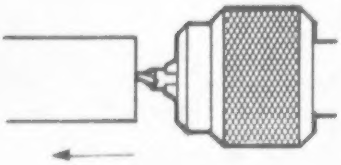
(NOTE: High-speed steel tools are used for higher speeds and carbon steel tools are used for average cutting.)

L. Travel--The movement of the carriage along the bed or the movement of the cross slide and compound rest across the carriage.

II. Basic lathe operations

A. Boring--Removing metal from the inside of the workpiece to enlarge the inside diameter or shape the inside.



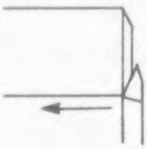


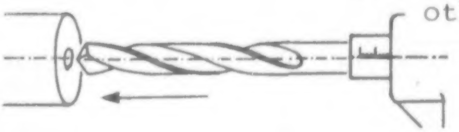
B. Center drilling--Producing a cone-shaped hole in the end of a workpiece.

(NOTE: This hole is used to center the workpiece when turning between centers or for alignment when starting a drill kit.)

C. Chamfering--Producing an angle on the edge of a workpeice.

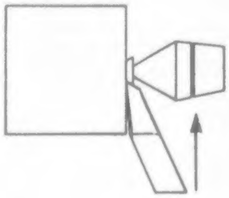
(NOTE: This is done for deburring and before threading a workpiece.

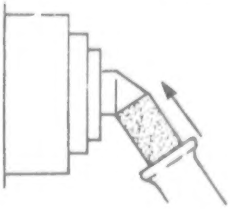




D. Drilling--Produce a hole in the workpiece so other operations may follow.

E. Facing--Squaring and smoothing the end of a workpiece.

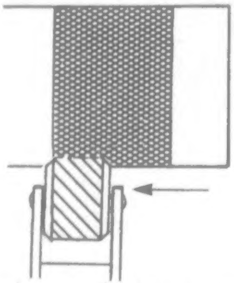


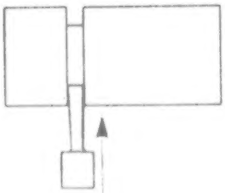


F. Grinding--Removing hardened metal on the lathe which could not be cut with regular lathe tools.

G. Knurling--Producing a rough pattern on the surface of the workpiece.

(NOTE: This is done to provide a gripping surface or to enlarge the diameter of the workpiece.)

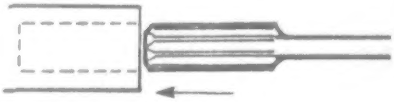




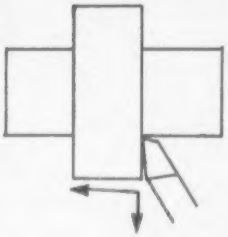
H. Parting--Cutting a workpiece into two pieces.

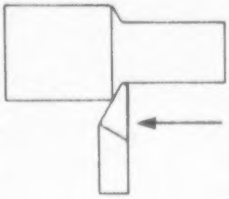
(NOTE: A parting tool is also used to cut grooves or recesses in the workpiece.)

I. Reaming--Smoothing the surfaces of a hole to an exact size.



J. Shoulder turning--Producing a square, angular, or rounded corner on a workpiece.

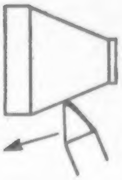


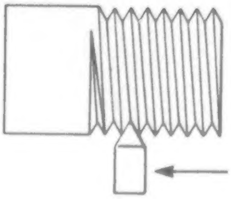


K. Straight turning--Removing metal a specified length on a workpiece to reduce its diameter.

L. Taper turning--Producing a cone shaped area on the workpiece.

(NOTE: The difference in diameters will be according to specified sizes.)





M. Threading--Producing V-shaped grooves around a workpiece that advance along the shaft specified distances.

(NOTE: Threads are placed on fasteners of all shapes.)

III. Things to consider when setting speeds and feeds.

A. Type of metal

(NOTE: Different types of metals vary in hardness which affects the cutting ability.)

B. Depth of cut

(NOTE: Feed is usually slower on larger cuts.)

C. Finish required

(NOTE: A slower feed with a faster RPM is used on finishing cuts and a slower feed with a slower RPM is used on roughing cuts.)

D. Type of cutter

(NOTE: Carbide cutters will stand higher RPM with faster feeds than tool steel cutters.)

UNIT II

LATHE OPERATIONS

ASSIGNMENT SHEET 1--FIGURING RPM

Directions: Using the chart or formulas shown below, determine the correct RPM for each situation given below.

A. Figure what RPM would be used for each problem below. Use the chart shown.

EXAMPLE: The RPM for turning a 1" diameter piece of stock with a cutting speed of 100 feet per minute would be 437.

TABLE OF CUTTING SPEEDS—REVOLUTIONS PER MINUTE

Feet per Min.	DIAMETER, INCHES											
	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 3/8	1 1/2	2	3
30	458	306	229	183	153	131	115	102	83.3	76.4	57.3	38.2
40	611	407	306	244	204	175	153	136	111	102	76.4	50.9
50	764	509	382	306	255	218	191	170	139	127	95.5	63.7
60	917	611	458	367	306	262	229	204	167	153	115	76.4
70	1070	713	535	428	357	306	267	238	194	178	134	89.1
80	1222	815	611	489	407	349	306	272	222	204	153	102
90	1375	917	688	550	458	393	344	306	250	229	172	115
100	1528	1019	764	611	509	437	382	340	278	255	191	127
125	1910	1273	955	764	637	546	477	424	347	318	239	159
150	2292	1528	1146	917	764	655	573	509	417	382	286	191
175	2674	1783	1337	1070	891	764	668	594	486	446	334	223
200	3056	2037	1528	1222	1019	873	764	679	556	509	382	255
250	3820	2546	1910	1528	1273	1091	955	849	694	637	477	318
300	4584	3056	2292	1833	1528	1310	1146	1019	833	764	573	382
350	5348	3565	2674	2139	1783	1528	1337	1188	972	891	668	446
400	6112	4074	3056	2445	2037	1746	1528	1358	1111	1019	764	509
500	7639	5093	3820	3056	2546	2183	1910	1698	1389	1273	955	637
600	9167	6112	4584	3667	3056	2619	2292	2037	1667	1528	1146	764

DIAMETER OF STOCK	CUTTING SPEED	RPM
1. 3/8"	80	
2. 1/2"	60	
3. 5/8"	40	
4. 3/4"	70	
5. 7/8"	100	
6. 1"	90	
7. 1 1/8"	125	
8. 1 3/8"	222	
9. 1 1/2"	60	
10. 3"	300	

B. Figure the RPM for each problem below. Use the formula:

$$RPM = \frac{4 \times \text{Cutting Speed}}{\text{Diameter of Stock}}$$

EXAMPLE: The RPM for a 1" diameter piece of mild steel stock with a cutting speed of 80 would be:

$$\frac{4 \times 80}{1"} = \frac{320}{1} = 320 \text{ RPM}$$

DIAMETER OF STOCK	CUTTING SPEED	RPM
1. 1"	100	
2. 1"	60	
3. 1½" (1.5)	90	
4. 2"	30	
5. 2½" (2.5)	70	
6. ¼" (.250)	80	
7. ½" (.500)	100	
8. 3"	300	
9. 3/8" (.375)	60	
10. 7/8" (.875)	70	

UNIT II

LATHE OPERATIONS

ASSIGNMENT SHEET 2--FIGURE TAPER PER FOOT

Directions: Use the following formula to figure the taper per foot (TPF) for each problem below.

$$\frac{\text{Large diameter - Small diameter}}{\text{length of taper}} \times 12 = \text{TPF}$$

EXAMPLE:

$$\frac{2 - \frac{1}{2}}{3} \times 12 = \text{TPF}$$

$$\frac{1\frac{1}{2}}{3} \times 12 = \text{TPF}$$

$$.5 \times 12 = \text{TPF}$$

$$6 = \text{TPF}$$

LARGE DIAMETER	SMALL DIAMETER	LENGTH OF TAPER	TAPER PER FOOT
A. 1.5"	1"	3"	
B. 1"	.750"	4"	
C. 1.125"	.625"	6"	
D. 2"	1.875"	5"	
E. .625"	.500"	3.500"	
F. 2.750"	2.1200"	4.250"	
G. 1.437"	1.200"	8"	
H. 3.12"	2.625"	2"	
I. 1.5"	1.375"	4.125"	
J. .750"	.250"	.875"	

UNIT II

LATHE OPERATIONS

ASSIGNMENT SHEET 3--FIGURE TAILSTOCK OFFSET

Directions: Use the formula shown below to figure the tailstock offset for each of the following problems.

$$\frac{\text{Length of workpiece}}{12} \times \frac{\text{Taper Per Foot}}{2} = \text{Offset}$$

LENGTH OF WORKPIECE	TAPER PER FOOT	OFFSET
A. 12"	.500	
B. 8"	.375	
C. 6"	.250	
D. 4"	1"	
E. 3.5"	3"	
F. 6.250"	.90"	
G. 5.875"	.375"	
H. 9.750"	2"	
I. 10"	4"	
J. 10.187"	4"	

UNIT II

LATHE OPERATIONS

JOB SHEET 1--SETUP FOR TURNING IN A CHUCK

I. Tools and equipment needed

A. Four-jaw chuck

B. Wood board

C. Chuck key

D. Rag

E. Oil can

F. Dial indicator or (wiggle stick--board with wire in the middle)

G. Piece of round stock

H. Tool steel (cutter bit or tool)

I. 0-1" micrometers

J. File

II. Procedure

A. Check to make sure the power is turned off.

B. Install the chuck

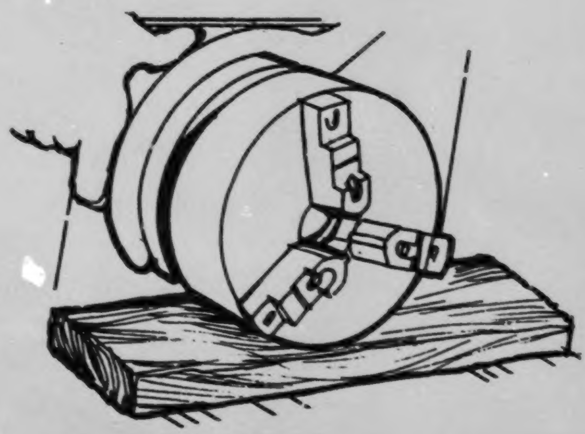
(NOTE: There are various types of fasteners used to attach chucks. Ask your instructor for assistance.)

1. Place a short board across the ways

2. Carefully place the chuck on the board

3. Wipe the mounting surfaces of the chuck and spindle with the rag

4. Fasten the chuck to the spindle



CAUTION: Make sure the chuck is securely fastened.

5. Remove the board and chuck key.

C. Place the stock in the chuck.

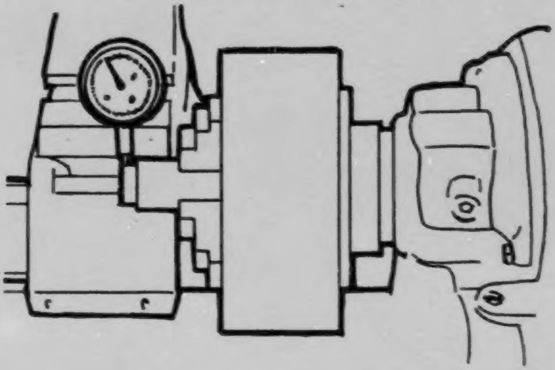
D. Align the stock by eye as close to center as possible.

E. Center the stock in the chuck.

1. Use the dial indicator to center the stock.

   a. Place the dial indicator on the carriage or ways of the bed.

   b. Place the pointer on the stock so that the needle in the dial will not be on zero.



   c. Roll the chuck slowly by hand.

   d. Watch the indicator dial and pointer.

   e. Stop the chuck when the indicator pointer is on the least number or value.

   f. Loosen the jaw of the chuck nearest you.

   (NOTE: As you loosen the jaw, watch the pointer of the indicator so that it does not move too far.)

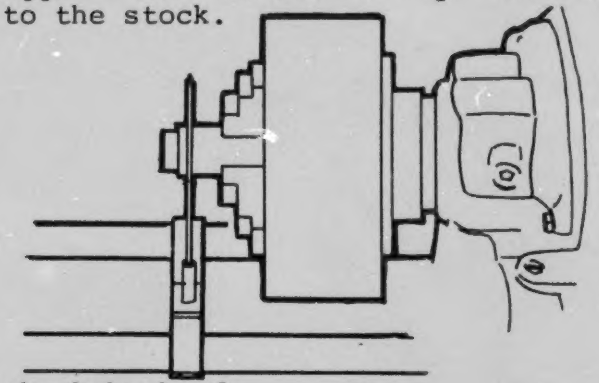
   g. Tighten the jaw opposite the one loosened.

   h. Repeat this process of loosening the jaws on the side of the indicator when it shows the least value.

   (NOTE: The amount you loosen the jaws should decrease each time until the stock is centered and the dial pointer does not move.)

2. Use the wiggle stick to center the stock.

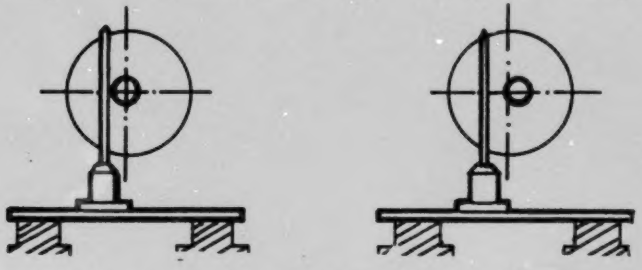
a. Place the wiggle stick across the ways with the wire close to the stock.



b. Rotate the chuck by hand.

c. Watch the stock move near and then away from the wire.

d. Stop the chuck when the stock is away from the wire.



e. Slightly loosen the jaw closest to you.

f. Tighten the opposite jaw.

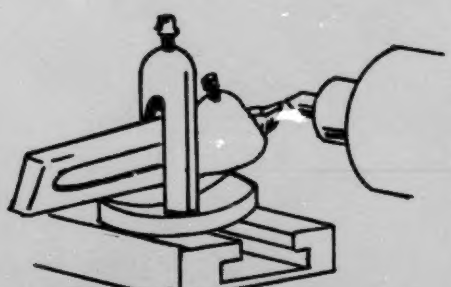
g. Repeat this process of loosening and tightening the stock until there is no noticeable movement of the stock to and from the wire.

(NOTE: You may move the wire closer to the stock for finer alignment.)

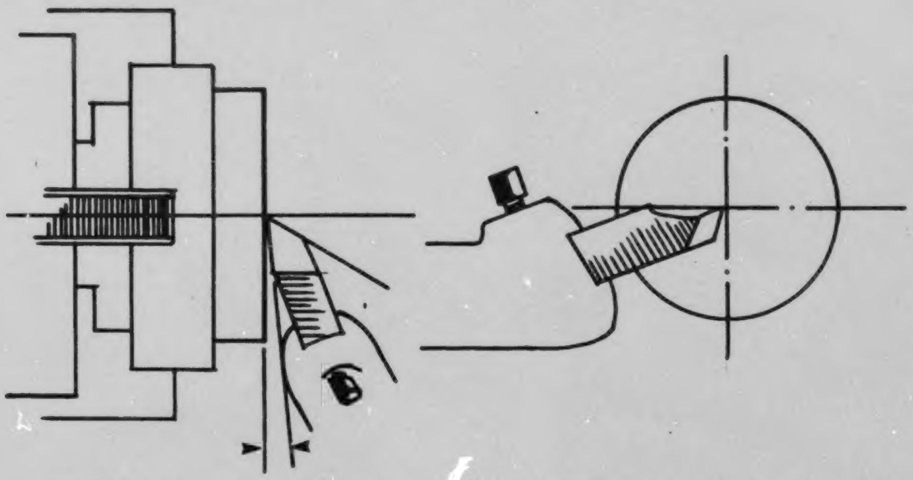
F. Face the stock

1. Place the cutter tool or bit in a right-hand tool holder and then in the tool post.

2. Align the point of the tool with the dead center for facing.



3. Align the tool with proper side clearance.

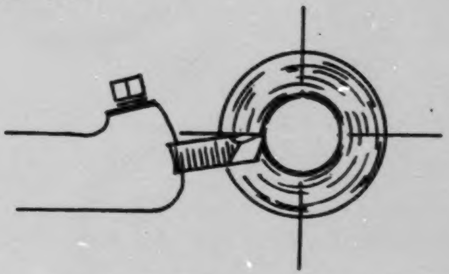


CAUTION: The tool holder must be securely fastened in the tool post

4. Set the RPM for the diameter of the stock.

5. Start the lathe and move the tool into position for a light cut.

6. Feed the tool toward the center of the stock with the cross-feed crank.



(NOTE: Use a slower feed to produce a finishing cut.)

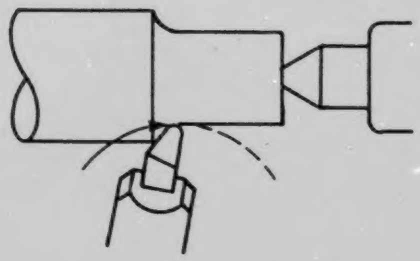
G. Take a cut along the length of the stock.

1. Place a roughing tool in a left-hand tool holder and the holder in the tool post.

2. Align the point of the tool with the dead center and at a right angle to the stock.

   (NOTE: Securely tighten the tool holder and tool post.)

   CAUTION: The tool must be at a right angle to prevent the tool from swinging into the stock if the tool post moves.



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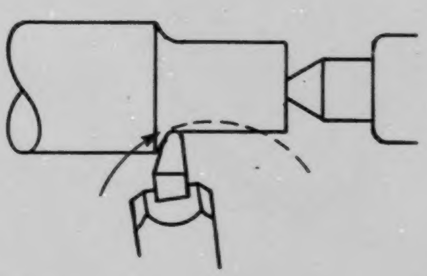


wrong

3. Set the RPM for the diameter of the stock.

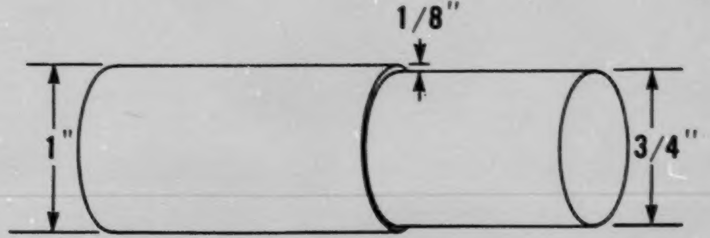
4. Start the lathe and move the tool into position so that it lightly scratches the stocks surface.

5. Zero the cross slide dial.

   CAUTION: Make sure the tool clears the workpiece when making adjustments.

6. Move the cross-feed crank enough to make a roughing cut.

   (NOTE: Ask your instructor if the lathe crossfeed is a direct or indirect reading dial because the diameter is reduced by twice the amount of the depth of the cut.)



7. Make one roughing cut pass to the specified length.

8. Move the tool back to the starting point and stop the lathe.

9. Measure the diameter with the micrometer.

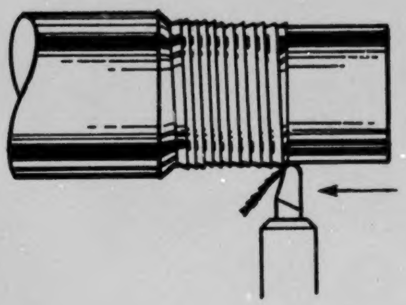
10. Dial in the correct amount for a finishing cut.

    (NOTE: Approximately .015 to .020 inch should be left for a finish cut, so several roughing cuts may be necessary to reach the desired size.)

11. Change the tool to a finishing tool.

12. Align the tool and make a finishing pass.

    (NOTE: Feed speed is reduced and RPMs are increased for finishing.)



H. Remove the burrs with a file.

I. Remove the workpiece and turn in to your instructor.

J. Clean the lathe and turn in the tools.

LATHE OPERATIONS

JOB SHEET 2--SETUP FOR TURNING BETWEEN CENTERS

I. Tools and equipment

A. Face plate

B. Lathe dog

C. Board

D. Rag

E. Oil can

F. Piece of round stock

G. Center drill

H. Drill chuck

I. Three-jaw chuck

J. Chuck key

K. Cutter bit or tool

L. 0-1" micrometers

M. File

N. Dead centers (bushing for headstock,if required)

O. Tool holder

II. Procedure

A. Check to make sure the power is turned off

B. Install the three-jaw chuck

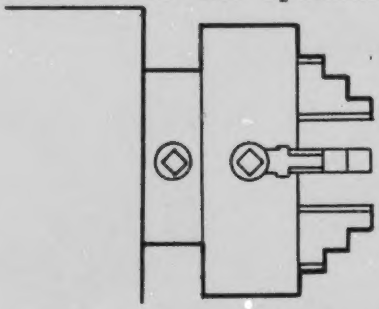
(NOTE: There are various types of fasteners used to attach chucks. Ask your instructor for assistance.)

1. Place a short board across the ways.

2. Carefully place the three-jaw chuck on the board.

3. Wipe the mounting surfaces of the chuck and spindle with a rag.

4. Fasten the chuck to the spindle



CAUTION: Make sure the chuck is securely fastened.

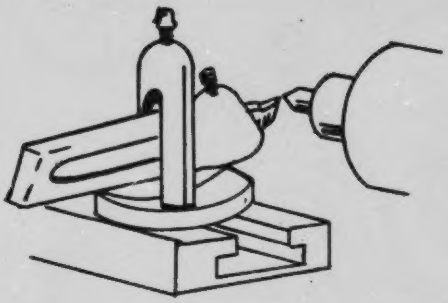
C. Place the stock in the chuck and tighten securely.

(NOTE: The three-jaw chuck will center the stock for drilling.)

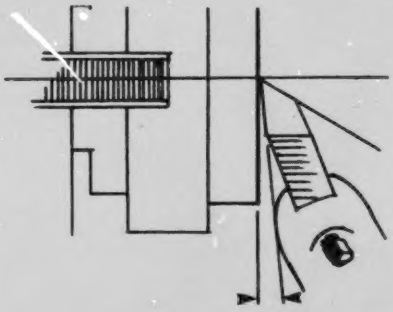
D. Face the stock

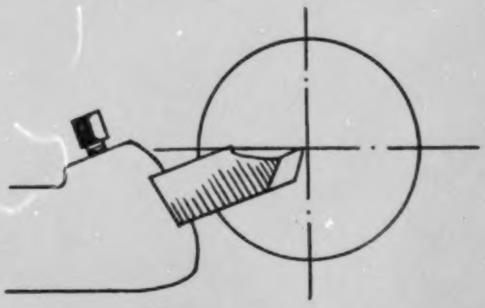
1. Place the cutter tool in a right-hand tool holder and in the tool post.

2. Align the point of the tool with the dead center for facing.



3. Align the tool with the proper side clearance.



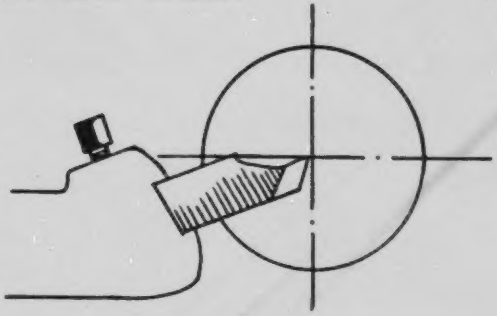


CAUTION: The tool holder must be securely fastened in the tool post.

4. Set the RPM for the diameter of the stock.

5. Start the lathe and move the tool into position for a light cut.

6. Feed the tool toward the center of the stock with the cross-feed crank.

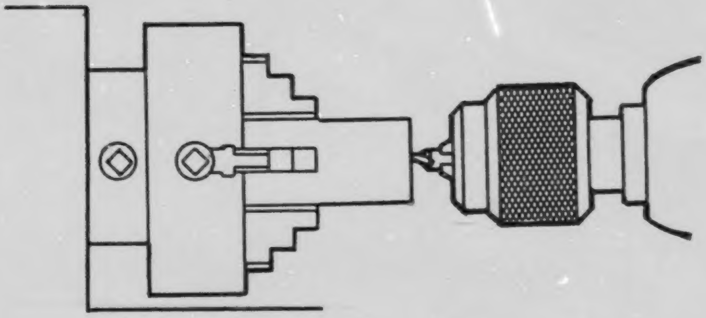


(NOTE: Use a slower feed to produce a finishing cut.)

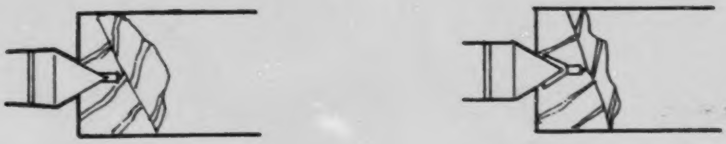
E. Center drill the stock

1. Place the center drill in the drill chuck.
2. Place the drill chuck in the tailstock.
3. Lock the tailstock into drilling position.

   CAUTION: Make sure the tool and tool holder are clear from the chuck.



4. Drill into the stock the proper depth.



correct

incorrect

F. Turn the stock around in the chuck.

G. Face the other end.

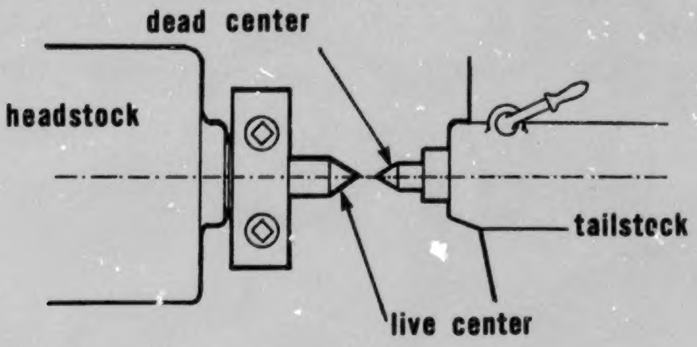
H. Center drill the other end.

I. Place the stock between centers

1. Remove the chuck from the headstock.
2. Place the centers in the headstock and tailstock.

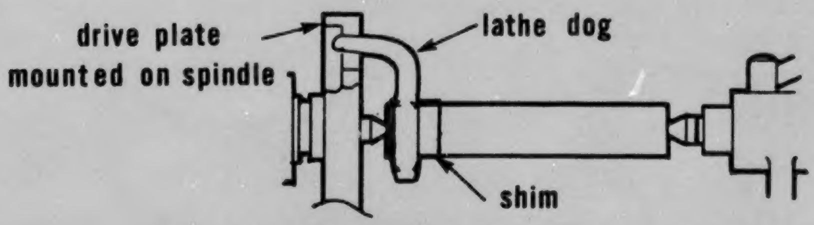
   (NOTE: Wipe the centers and spindles with a rag before installing the centers. A bushing may be required for the headstock center.)

3. Check the centers for proper alignment.

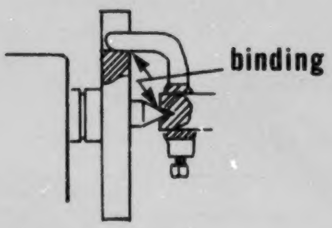

dead center
headstock
tailstock
live center

   (NOTE: If the centers are not aligned, adjust the tailstock offset screws until the centers are aligned.)

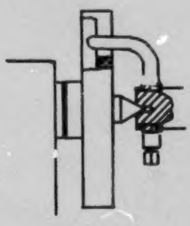
4. Mount the face plate on the spindle.
5. Place a metal shim around the workpiece on the end of the lathe dog.
6. Securely fasten a lathe dog in place on the metal shim.
7. Place the stock between centers.


drive plate
mounted on spindle
lathe dog
shim

8. Check the lathe dog and face plate for binding.



incorrect



correct

9. Lubricate the dead center and tighten the tailstock in place.

(NOTE: White lead is often used as a lubricant for the dead center. Ball bearing centers are often used in place of a dead center.)

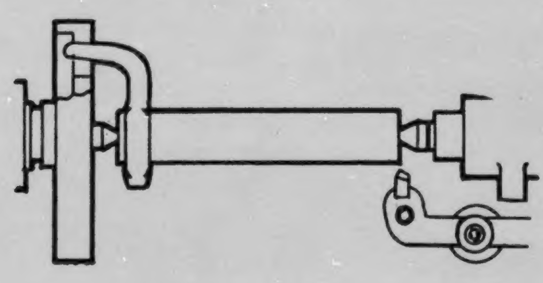
CAUTION: Tighten the tailstock so that the stock will move on the centers by hand but tight enough so it will not have end slack.

J. Cut the stock to the specified size.

1. Place a roughing tool in a left-hand tool holder and the tool holder in the tool post.

2. Align the point of the tool with the dead center and at a right angle to the stock.

(NOTE: Securely tighten the tool and tool post.)



CAUTION: The tool must be at a right angle to the work to prevent the tool from swinging into the stock if the tool post moves.

3. Set the RPM for the diameter of the stock.

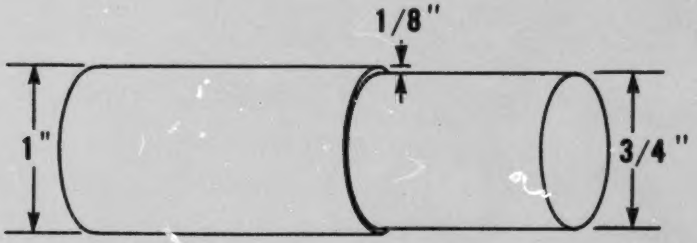
4. Start the lathe and move the tool into position so that it lightly scratches the stocks surface.

5. Zero the cross slide dial.

CAUTION: Make sure the tool clears the workpiece when making adjustments.

6. Move the cross-feed crank enough to make a roughing cut.

(NOTE: Ask your instructor if the lathe cross-feed is a direct or indirect reading dial, because when a cut is taken, the diameter is reduced by twice the amount of the depth of the cut.)



7. Make one roughing cut pass to the lathe dog.

CAUTION: Stop the feed before the tool holder gets close to the lathe dog.

8. Move the tool back to the starting point and stop the lathe.

9. Measure the diameter with the micrometer.

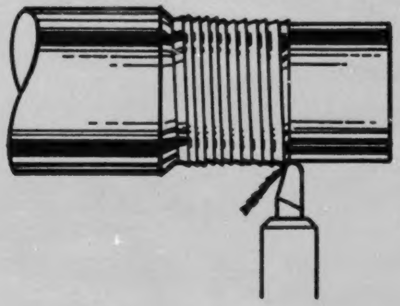
10. Dial in the correct amount for finishing cut.

(NOTE: Approximately .015 to .020 inch should be left for a finish cut, so several roughing cuts may be necessary to reach the desired size.)

11. Change the tool to a finishing tool.

12. Align the tool and make a finish pass.

(NOTE: Feed speed is reduced and RPMs are increased for finishing.)



K. Place the lathe dog on the other end of the stock and place the stock between centers for turning the other end to size.

L. Remove burrs with a file.

M. Remove the workpiece and turn in to your instructor.

N. Clean the lathe and turn in the tools.

LATHE OPERATIONS

JOB SHEET 3--SETUP FOR TURNING ON A MANDREL

I. Tools and equipment

   A. Mandrel

   B. Workpiece (with a drilled and reamed hole)

   C. Face plate

   D. Lathe dog

   E. Board

   F. Rag

   G. Oil can

   H. Cutter bit

   I. Dead centers

   J. Tool holders

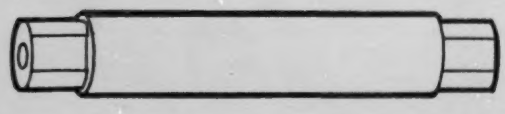
   K. File

   L. Measuring tools

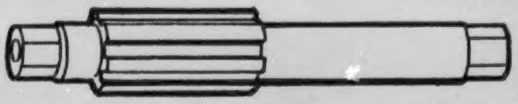
II. Procedure

   A. Select a mandrel that will allow a press fit of the workpiece.

   (NOTE: A solid or expansion mandrel may be used, as long as the size will provide a press fit in the workpiece.)



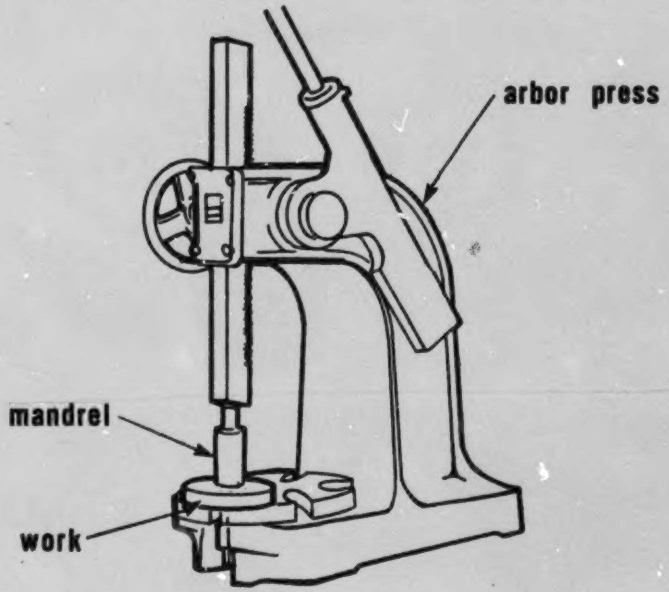
solid



expansion

B. Press the mandrel in the hole on the workpiece.

CAUTION: Lubricate the hole and mandrel with oil.

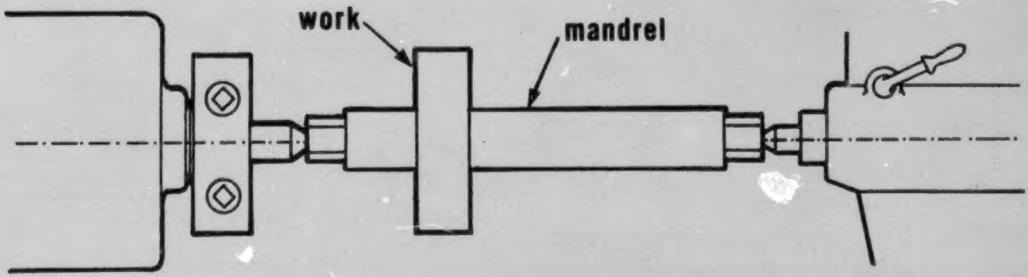


(NOTE: The mandrel should be pressed into the hole of the workpiece so that it is tight and will not slip on the mandrel.)

C. Place the mandrel between centers.

(NOTE: See JOB SHEET 2--SETUP FOR TURNING BETWEEN CENTERS for procedures.)

CAUTION: Make sure the power is turned OFF.



D. Face the right side of the stock.

CAUTION: Do not allow the cutting tool to cut the mandrel.

E. Turn the mandrel around in the centers to face the other side of the workpiece.

F. Turn the outside diameter of the workpiece to the desired size.

G. Remove burrs with a file.

H. Remove the workpiece and mandrel from the lathe.

I. Press the mandrel out of the workpiece.

(NOTE: Remember the mandrel is tapered and the workpiece should be pressed off the small end.)

J. Hand in the workpiece to your instructor.

K. Clean the lathe and turn in tools.

UNIT II

LATHE OPERATIONS

JOB SHEET 4--SETUP FOR TURNING A TAPER

I. Tools and equipment

- A. Four-jawed chuck
- B. Cutter bit
- C. Face plate
- D. Lathe dog
- E. Lathe centers
- F. Tool holder
- G. Board
- H. Rag
- I. Oil can
- J. Piece of round stock
- K. Micrometers
- L. Drill chuck
- M. Center drill
- N. File
- O. Chart (below)

Taper per foot	Angle included		Angle with center line		Taper per inch from center line
	Degrees	Minutes	Degrees	Minutes	Inches
1/8......	0	36	0	18	0.01042
3/16.....	0	54	0	27	.01563
1/4......	1	12	0	36	.02083
5/16.....	1	30	0	45	.02604
3/8......	1	47	0	54	.03125
7/16.....	2	5	1	3	.03646
1/2......	2	23	1	12	.04167
9/16.....	2	41	1	21	.04688
5/8......	3	0	1	30	.05208
11/16....	3	17	1	38	.05729
3/4......	3	35	1	47	.06250
13/16....	3	53	1	56	.06771
7/8......	4	11	2	5	.07292
15/16....	4	28	2	14	.07813
1........	4	46	2	23	.08333
2........	9	32	4	46	.16667

II. Procedure

A. Figure taper per foot for tapered portion of workpiece.

(NOTE: The taper may also be specified in taper per inch or in degrees.)

B. Setup the workpiece to cut the taper.

CAUTION: Make sure the power is turned off.

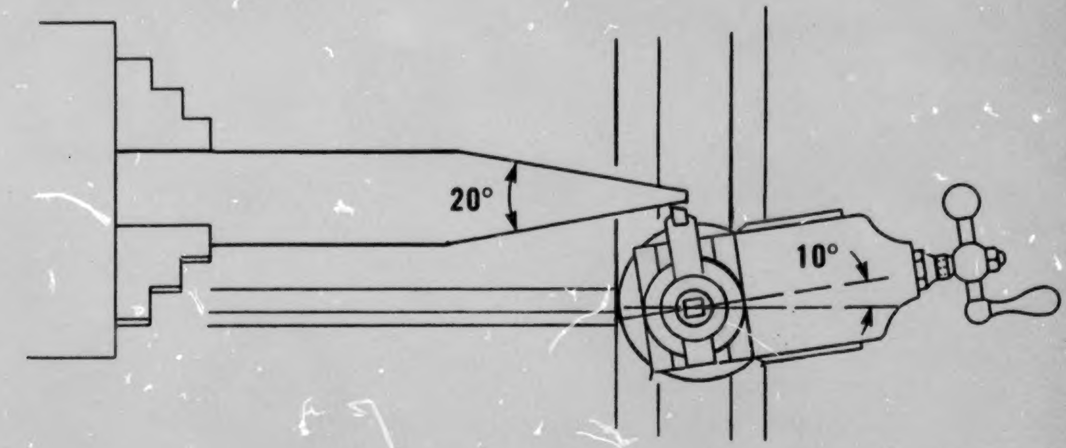
C. Compound rest method

(NOTE: This method is usually used for short tapers.)

1. Center the workpiece in the lathe chuck.

2. Set the compound rest to the correct angle.

   (NOTE: The angle should be set to 1/2 the number of degrees in the total included angle.)



3. Align the lathe tool at a right angle to the tapered portion to be cut.

4. Lock the carriage in place with the lock bolt.

D. Offset tailstock

(NOTE: Used to taper a workpiece which is turned between centers.)

1. Prepare the workpiece for turning between centers.

   (NOTE: See JOB SHEET 2--SETUP FOR TURNING BETWEEN CENTERS for procedures.)

2. Figure the set over for the workpiece.

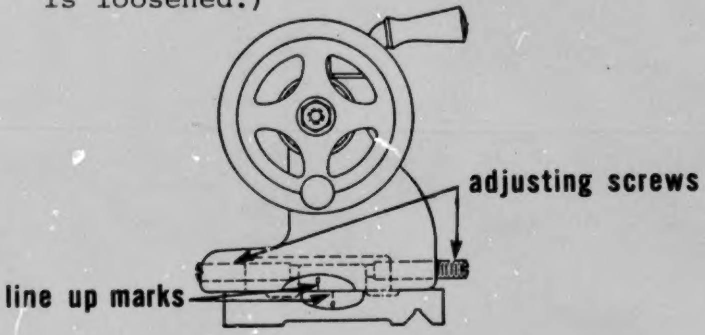
(NOTE: Use the formula:

$$\text{Set over} = \frac{\text{Length of workpiece in inches}}{12} \times \frac{\text{Taper per foot}}{2}$$

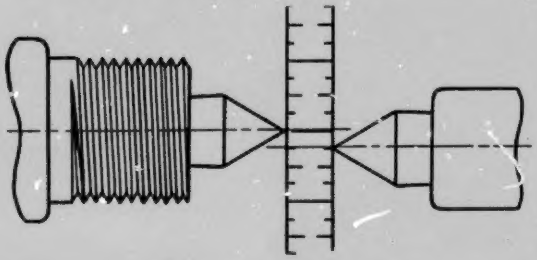
to get the offset for the tailstock.)

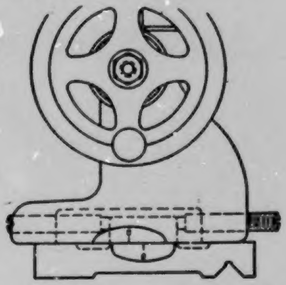
3. Move the tailstock off-center by loosening and tightening the adjusting screws on the tailstock.

   (NOTE: The tailstock will move toward the adjusting screw being tightened after the opposite screw is loosened.)

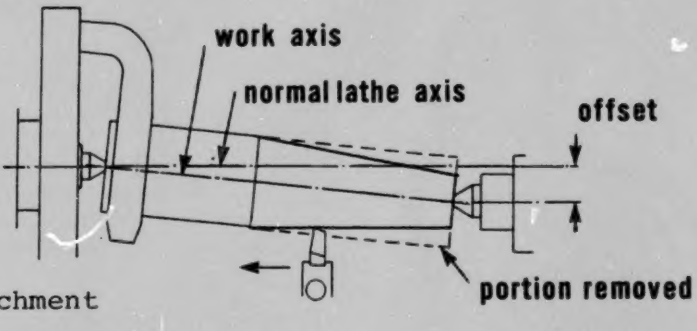

adjusting screws
line up marks

4. Adjust the tailstock to the correct set over.





5. Align the tool at a right angle to the tapered portion to be cut.


work axis
normal lathe axis
offset
portion removed

E. Taper attachment

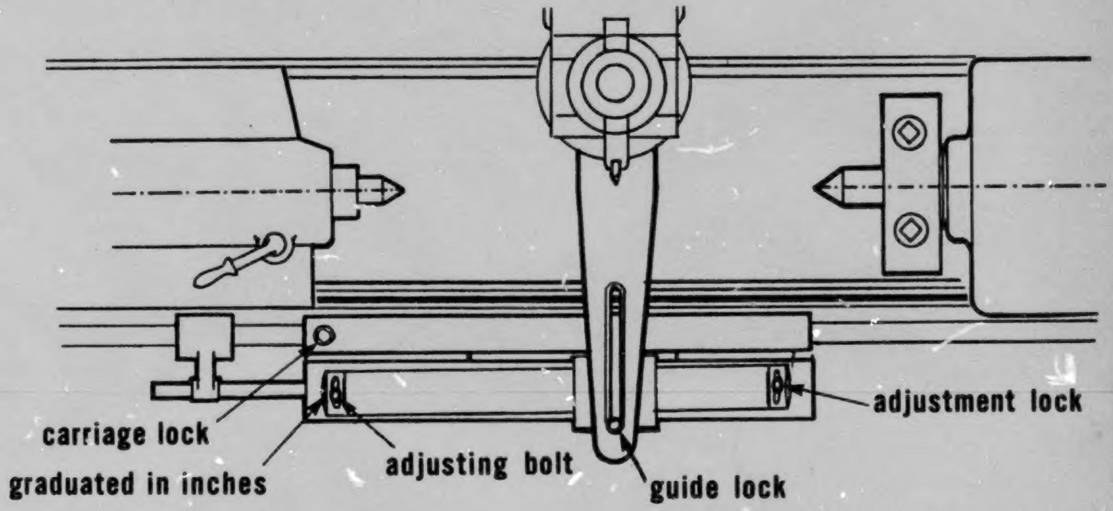
(NOTE: This is the most accurate method used to cut a taper on a workpiece in a chuck or between angles.)

1. Setup the workpiece to be turned.

   (NOTE: See JOB SHEET 1--SETUP FOR TURNING IN A CHUCK or JOB SHEET 2--SETUP FOR TURNING BETWEEN CENTERS.)

2. Loosen the taper attachment lock on the left end.

3. Adjust the taper attachment to the correct setting by turning the bolt on the right end.


adjustment lock
carriage lock
graduated in inches
adjusting bolt
guide lock

4. Lock the adjustment lock.

5. Align the tool at a right angle to the taper to be turned.

6. Lock the carriage in place.

F. Start the machine

CAUTION: Make sure all parts are securely tightened.

G. Move the tool into position at the start of the taper.

H. Begin cutting the taper by taking a light cut on the tapered area of the workpiece.

I. Take additional cuts until the tapered portion is the correct length.

J. Remove burrs with a file.

K. Stop the machine and remove the workpiece.

L. Clean up the lathe and turn in the tools.

M. Turn in the workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 5--SETUP FOR THREADING

I. Tools and equipment

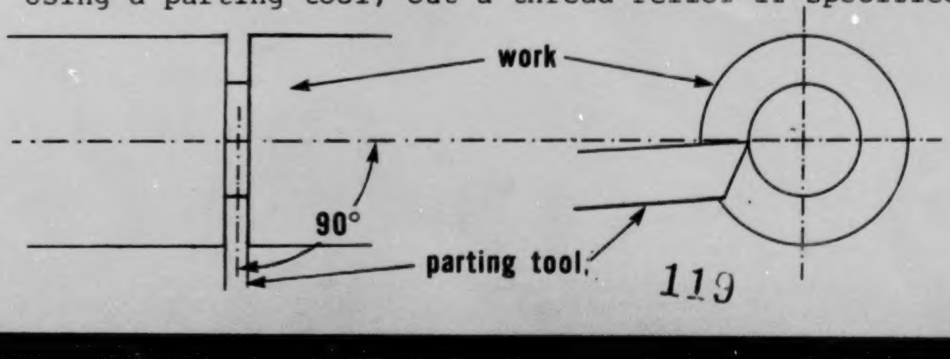
- A. Chuck or faceplate
- B. Lathe dog
- C. Lathe centers
- D. Straight tool holder
- E. Cutter bit
- F. Threading tool
- G. Center gage
- H. Parting tool
- I. Cutting oil
- J. Three-cornered file
- K. Parallel lathe file
- L. Shop rag

II. Procedure

CAUTION: Stop the lathe when making any adjustment.

- A. Check to make sure the power is turned off.
- B. Place the workpiece to be threaded in the lathe chuck or between centers.

  (NOTE: See JOB SHEETS 1 or 2 for procedures.)
- C. Face the workpiece to length.
- D. Turn the workpiece to the outside diameter required for threading.
- E. Using a parting tool, cut a thread relief if specified.

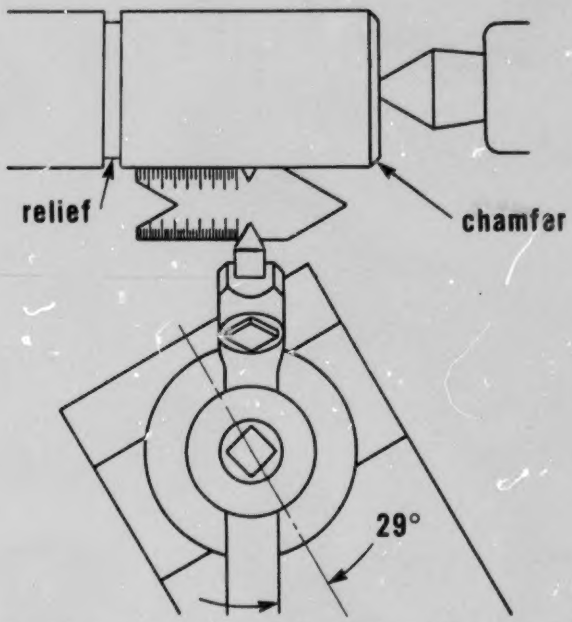


F. Set the compound rest on 29°.

G. Place the threading tool in a straight tool holder.

(NOTE: If a formed tool is used, it should be attached to the tool holder.)

H. Align the threading tool to the workpiece.



I. Set the lathe for the correct threading speed and chamfer the end of the section to be threaded.

(NOTE: Approximately 1/3 of the RPM for straight turning the diameter of the section to be threaded should be used.)

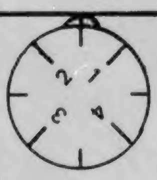
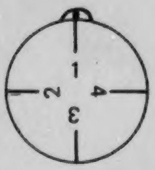
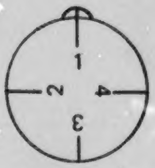
J. Move the point of the threading tool into position so it lightly scratches the surface of the section to be threaded.

K. Zero the compound rest and cross slide dials by holding the handles and turning the dials to 0.

L. Set the feed to the specified number of threads per inch.

M. Back the tool point away from the stock.

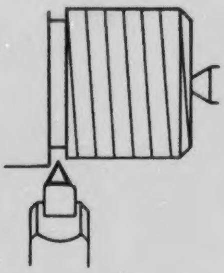
N. Select the correct number on the thread chasing dial for threading.

THREADS PER INCH TO BE CUT	WHEN TO ENGAGE SPLIT NUT	READING ON DIAL
EVEN NUMBER OF THREADS	ENGAGE AT ANY GRADUATION ON THE DIAL 1 1 1/2 2 2 1/2 3 3 1/2 4 4 1/2	
ODD NUMBER OF THREADS	ENGAGE AT ANY MAIN DIVISION 1 2 3 4	
FRACTIONAL NUMBER OF THREADS	ENGAGE AT EVERY OTHER MAIN DIVISION $\left.\begin{matrix}1\\3\end{matrix}\right\}\text{ or }\left\{\begin{matrix}2\\4\end{matrix}\right.$	

O. Figure the depth of the threads to be cut.

(NOTE: Use the formula: $\text{Depth} = \dfrac{\text{Number of threads per inch}}{.075}$)

P. Move the tool back to the zero point and take a light cut by engaging the half-nut at the number selected on the thread chasing dial.



(NOTE: When the threading tool reaches the end of the section to be threaded, disengage the half-nut lever.)

Q. Back the tool away from the workpiece with the crossfeed crank.

(NOTE: The tool should not hit the threaded area.)

R. Return the carriage to the starting point and the threading tool to the zero point.

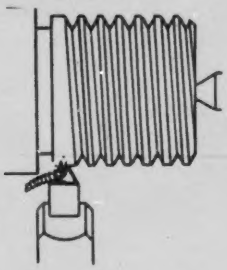
S. Feed the threading tool in .005 with the compound rest crank.

T. Take another cut and return the tool to the starting point.

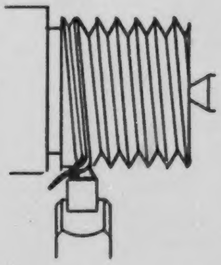
(NOTE: Apply cutting oil before each pass.)

U. Take additional cuts of .005.

(NOTE: Each time, the tool should be backed out, returned to the starting point, and fed in another .005.)

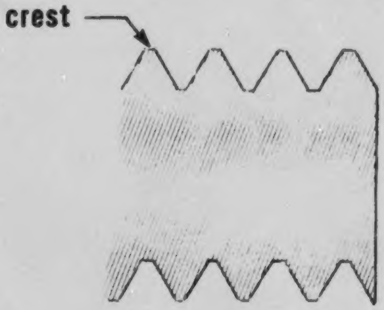


V. When the threads form a point, make a finishing pass without dialing in the compound rest.



W. File a narrow flat (crest) on top of the threads with a lathe file.

(NOTE: Check the threads for smoothness and file with three-cornered file if necessary.)



X. Check the threads with threaded nut with the same thread specificiations.

Y. Clean up the lathe and turn in tools.

Z. Hand in the workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 6--SETUP FOR DRILLING, REAMING, AND BORING

I. Tools and equipment

  A. Chuck (3- or 4-jaw)

  B. Boring bar and holder

  C. Tool steel (right-hand facing tool)

  D. Right-hand tool holder

  E. Drill chuck and center drill

  F. Pilot drill (diameter should be the size of the point on the large bit)

  G. Large drill bit (undersize of finished hole)

  H. Reamer (undersize of finished hole)

  I. Workpiece

  J. Shop rag

  K. Coolant or cutting oil

  L. Telescoping gauges

  M. Micrometer (0-1)

II. Procedures

  CAUTION: Stop the lathe when making any adjustments.

  A. Chuck the workpiece

  (NOTE: The workpiece should have as little as possible extending from the chuck.)

  B. Set the correct feed and speed for facing.

  C. Face the workpiece to length.

  D. Center drill the workpiece.

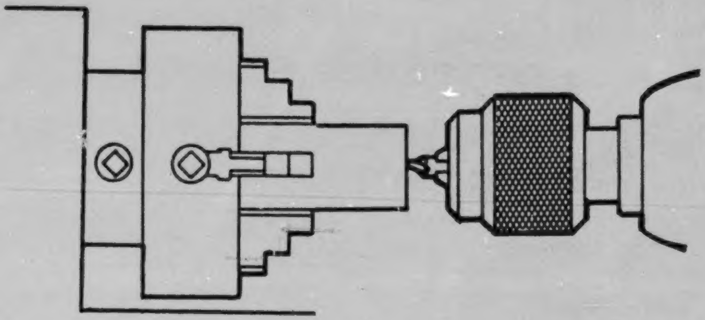
    1. Set the RPM for the diameter of the center drill.

    2. Place the centerdrill in the drill chuck.

    3. Place the drill chuck in the tailstock.

    4. Lock the tailstock in position.

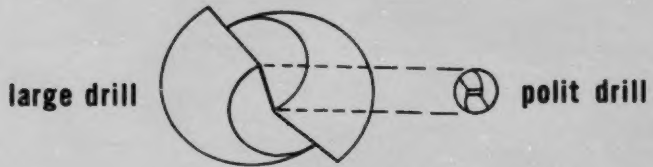
5. Center drill the workpiece.



E. Pilot drill the workpiece

1. Set the RPM for the diameter of the pilot drill.

   (NOTE: Select a pilot drill that is the size of the point of the large drill.)



2. Place the pilot drill in the drill chuck.

3. Position the tailstock for drilling.

4. Lock the tailstock in position.

5. Drill to the correct depth.

   (NOTE: Use coolant or cutting oil on the drill bit.)

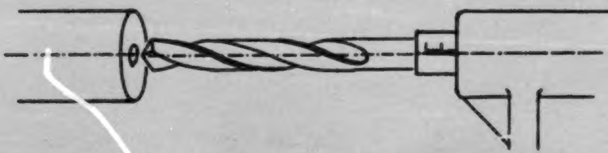
6. Back the drill out often and apply more coolant.

F. Drill the large hole.

1. Set the RPM for the diameter of the drill.

2. Place the tapered shank drill in the tailstock.

   (NOTE: A tapered sleeve may be required to adapt the drill to the tailstock.)



3. Position the tailstock for drilling.

4. Lock the tailstock in place.

5. Drill to the correct depth.

   (NOTE: The tailstock spindle has graduations on it for accurate measurement.)

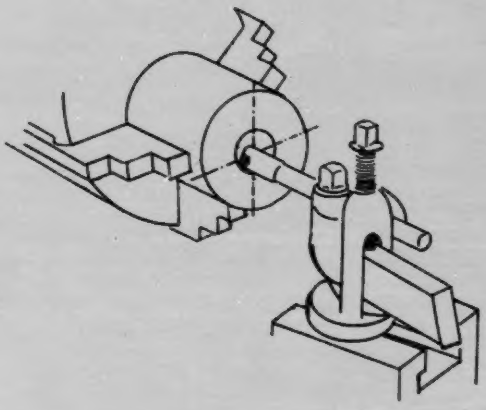
G. Bore the hole to the specified size.

(NOTE: If reaming is required, leave .015 for clean up.)

1. Set the RPM for the boring operation.

2. Place the boring bar in the tool post.

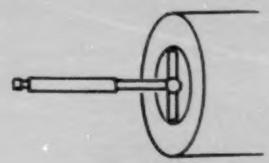
   (NOTE: The point of the cutting tool should be on center or slightly above.)

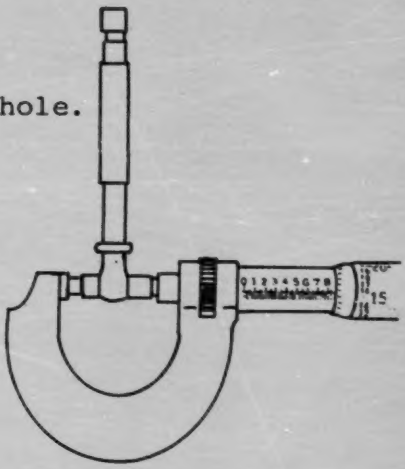


3. Position the tool for boring.

4. Zero the point of the tool in the hole.

5. Measure the diameter of the hole.





6. Set the cross slide for the first cut.

   (NOTE: Remember to dial out rather than feed in the cross slide.)

7. Take a cut.

   CAUTION: Be sure the tool does not hit the back of the hole.

8. Take additional cuts until the hole is the correct diameter.

   (NOTE: Leave .015 for reaming.)

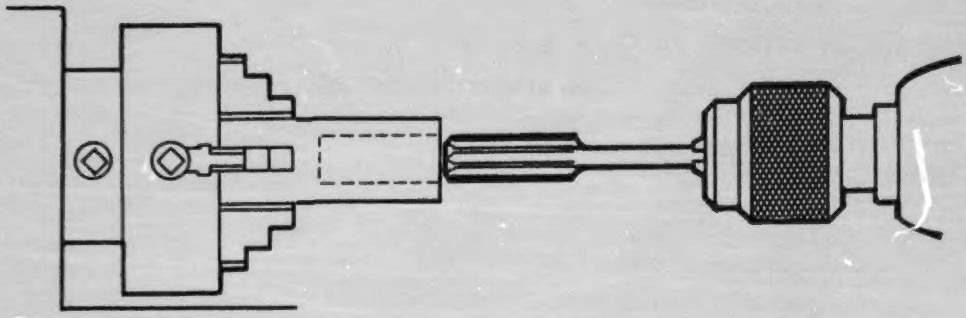
H. Ream the hole

1. Set the RPM for the reamer operation.

2. Place the reamer in the tailstock.

   (NOTE: Reamers may have tapered or straight shanks. The drill chuck should be used to hold straight shank reamers.)

3. Position the tool for reaming.



4. Lock the tailstock in place.

5. Ream to correct depth.

6. Check the hole with the telescoping gauges and micrometer.

I. Clean-up the lathe and turn in the tools.

J. Turn in the workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 7--SETUP FOR PARTING

I. Tools and equipment

  A. Chuck (3- or 4-jaw)

  B. Parting tool and holder

  C. Workpiece

  D. Cutting oil

  E. Shop rag

II. Procedure

CAUTION: Stop the lathe when making any adjustments.

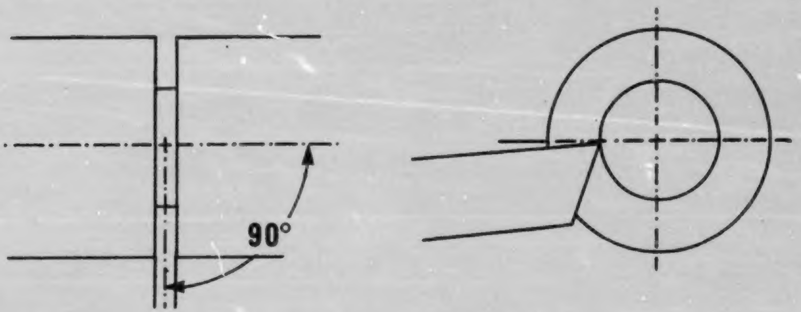
  A. Chuck the workpiece

  (NOTE: The workpiece should have as little as possible extending from the chuck.)

  B. Set the correct feed and speed for parting.

  (NOTE: The slowest RPM and feed should be used.)

  C. Align the parting tool at 90° and on center to the workpiece.



  D. Set the parting tool at the correct location.

  (NOTE: Allow for the width of the blade.)

  E. Lock carriage in position.

  F. Zero the tip of the parting tool.

  G. Start the lathe and begin feeding the tool into the stock.

  (NOTE: The tool may be hand-fed or power-fed into the workpiece.)

H. Apply coolant or cutting oil often.

I. Ease up on the feed as the tool nears the end of the cut.

J. Unlock the carriage.

K. Remove burrs from the workpiece.

L. Clean up the lathe and turn in the tools.

M. Hand in your workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 8--SETUP FOR KNURLING

I. Tools and equipment

- A. Chuck (3- or 4-jaw)
- B. Knurling tool and holder
- C. Workpiece
- D. Cutting oil
- E. Shop rag

II. Procedures

CAUTION: Stop the lathe when making any adjustments.

A. Chuck the workpiece.

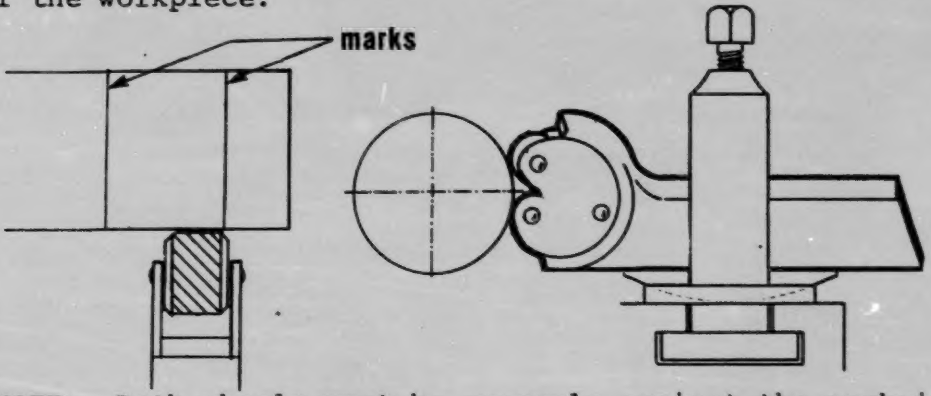
(NOTE: The workpiece should have as little as possible extending from the chuck.)

B. Setup the correct feed and speed for knurling.

(NOTE: The RPM should be as slow as possible and a fast feed.)

C. Mark off the section of the workpiece to be knurled.

D. Place the tool in the tool post so it is 90° and on center of the workpiece.



(NOTE: Both wheels must be squarely against the workpiece.)

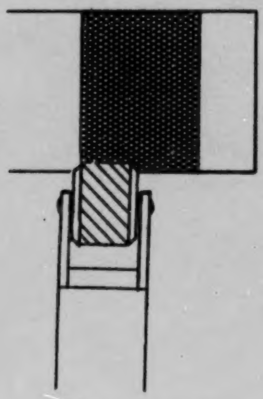
E. Start the lathe and dial the crossfeed toward the workpiece until a pattern is clearly formed.

F. Start the automatic feed.

G. Apply coolant or cutting fluid often.

H. Stop the machine when the knurls reach the left mark.

(NOTE: Do not disengage the feed.)



I. Reverse the spindle direction and apply more crossfeed pressure.

J. Stop the tool at the right starting point.

K. Make additional passes until the specified knurl is formed.

L. Clean up the lathe and turn in the tools.

M. Turn in the workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 9--SETUP FOR TOOL POST GRINDING

I. Tools and equipment

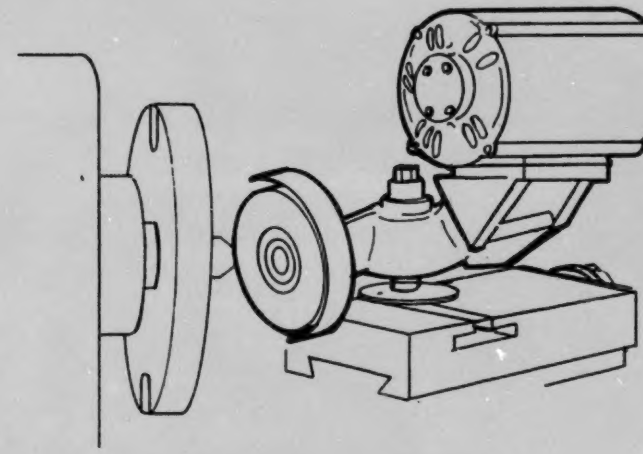
- A. Tool post grinder
- B. Workpiece (or lathe center)
- C. Shop rag

II. Procedures

CAUTION: Stop the lathe when making any adjustments.

- A. Place the center in the headstock.

  (NOTE: Remove the faceplate or chuck.)
- B. Align the toolpost grinder at 90° to the compound rest and fasten securely.
- C. Adjust the compound rest to a 30° angle from center line.



- D. Reverse the direction of rotation of the lathe spindle.
- E. Set the RPM of the lathe.
- F. Adjust the grinder to the starting point.
- G. Start the lathe and the grinder.

H. Feed the grinder into the center with the cross slide.

(NOTE: Avoid heavy cuts.)

I. Feed the grinder along with the compound rest crank.

J. Make several passes until the workpiece is smoothly evenly ground.

(NOTE: Be sure to move the grinder away from the workpiece before stoping the lathe.)

K. Clean up the lathe and turn in the tools.

L. Hand in the workpiece to your instructor.

UNIT II

LATHE OPERATIONS

JOB SHEET 10--FILING AND POLISHING

I. Tools and equipment

- A. Chuck (3- or 4-jaw)
- B. Workpiece
- C. Parallel lathe file
- D. Emery cloth
- E. File cord
- F. Micrometers

II. Procedures

CAUTION: Stop the lathe before making any adjustments.

A. Chuck the workpiece

CAUTION: When filing or polishing a workpiece between centers, stay clear of the lathe dog.

B. Filing

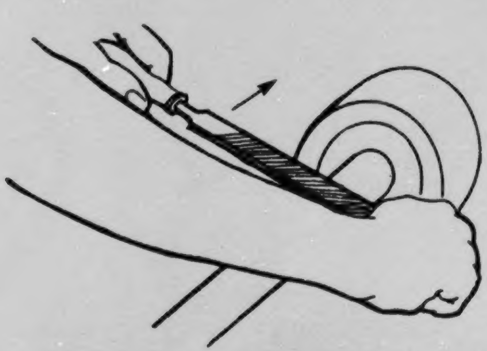
1. Set the RPM at the correct speed for filing.

   (NOTE: The RPM should be run faster for filing and polishing if the workpiece can be rotated at high speeds.)

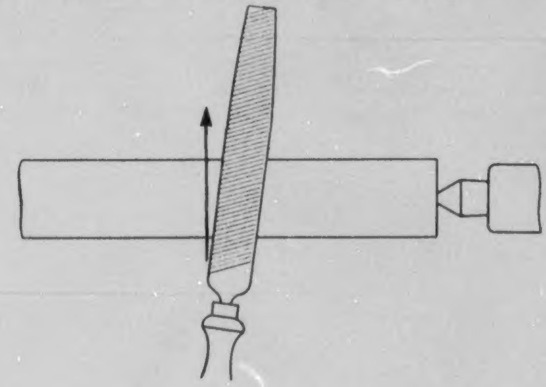
2. Start the lathe

   (NOTE: Move the carriage out of the way.)

3. File across the workpiece at an angle from the tailstock end of the lathe.



4. Use long strokes with a slight angle on the file.



5. File the workpiece to within .001 to .002 for polishing.

C. Polishing

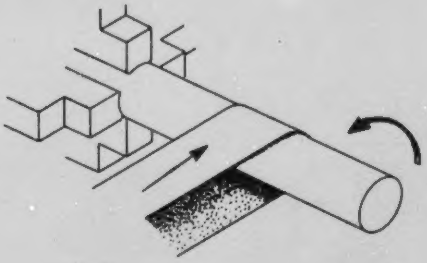
1. Set the RPM at the correct speed for polishing.

(NOTE: Run the lathe at 3,000 to 5,00 RPM for polishing.)

2. Start the lathe

(NOTE: Move the carriage out of the way.)

3. Place the emery cloth around the workpiece.



4. Move the emery cloth back and forth and up and down the length of the workpiece.

5. Stop the machine and check the workpiece several times during polishing.

6. Polish the workpiece to the specified diameter.

D. Clean up the lathe and turn in the tools.

E. Hand in the workpiece to your instructor.

LATHE OPERATIONS

JOB SHEET 11--CLEANING AND LUBRICATING THE LATHE

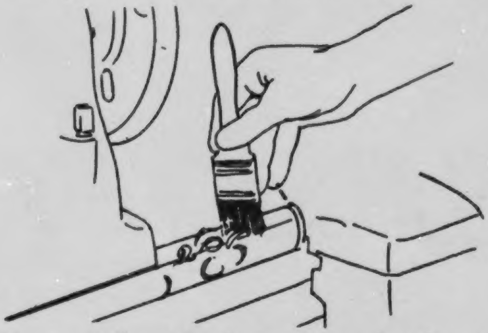
I. Tools and equipment

- A. Cleaning brush
- B. Shop rag
- C. Oil can
- D. Cleaning solvent
- E. Broom
- F. Dust pan
- G. Floor sweep

II. Procedures

CAUTION: Stop the lathe before making any adjustments.

A. Brush all chips from the carriage and ways.

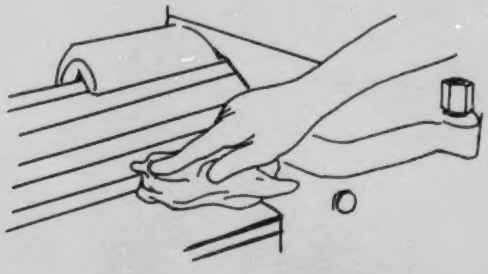


B. Wipe all dirt and oil from the lathe with a shop rag.

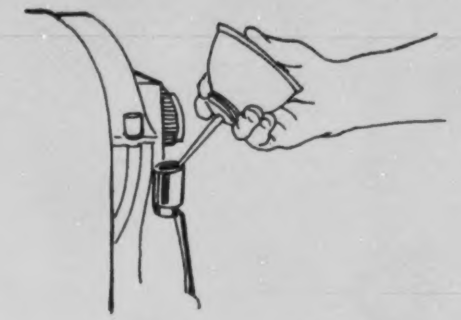
C. Wipe the lathe down with clean solvent.

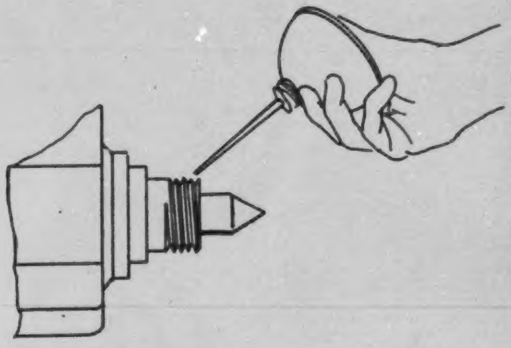
D. Dry the lathe with a shop rag.

E. Apply a thin coat of oil to the ways and ground surfaces of the lathe.



F. Oil spindle threads or cams and any oilers on the lathe.





(NOTE: Some lathe headstocks and carriages have oil sight glasses and should be checked regularly.)

G. Oil the motor and other oilers in the motor housing if required.

H. Wipe off the exterior surfaces of the lathe.

I. Sweep up chips around the lathe.

J. Pick up chips with the dust pan.

K. Sprinkle floor sweep on any oily spots.

L. Place cleaning rags, solvent, oil, and equipment in proper storage.

UNIT II

LATHE OPERATIONS

ANSWERS TO ASSIGNMENTS

Assignment 1

A. 1. 815
2. 458
3. 244
4. 357
5. 537
6. 344
7. 424
8. 80
9. 153
10. 382

B. 1. 400
2. 240
3. 240
4. 60
5. 112
6. 1280
7. 800
8. 400
9. 640
10. 320

Assignment 2

A 1.99
B. .75
C. .99
D. .30
E. .42
F. 1.76
G. .35
H. 2.97
I. .36
J. 6.85

Assignment 3

A. .25
B. .12
C. .06
D. .16
E. .43
F. .23
G. .09
H. .81
I. 1.66
J. 1.69

UNIT II

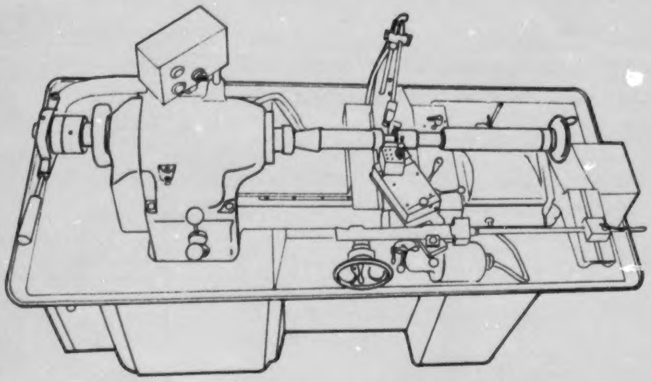
LATHE OPERATIONS

TEST PART 1

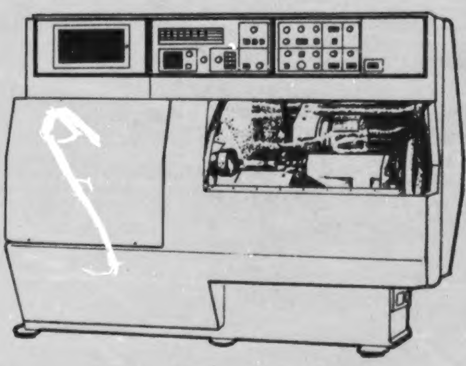
1. Explain the basic operation of the engine lathe.

2. Identify the types of lathes used in industry by writing each of the following names by the correct illustration.

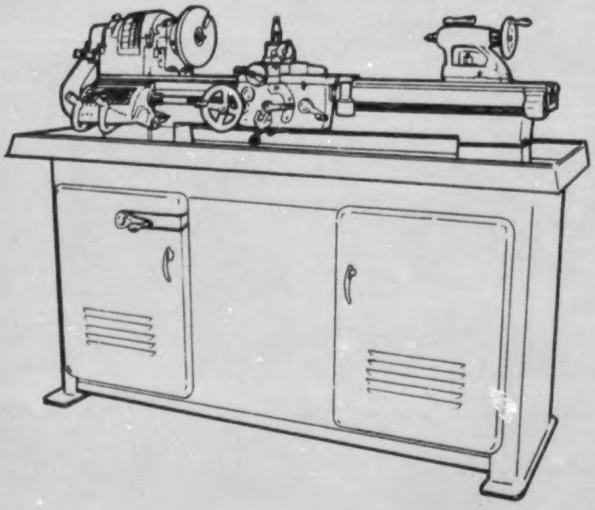
Engine	Numerical Control	Tracer
Turret



a. ______________________________

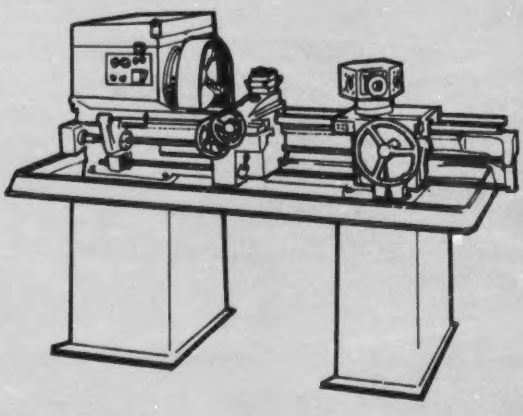


b. ______________________________



c. ______________________________

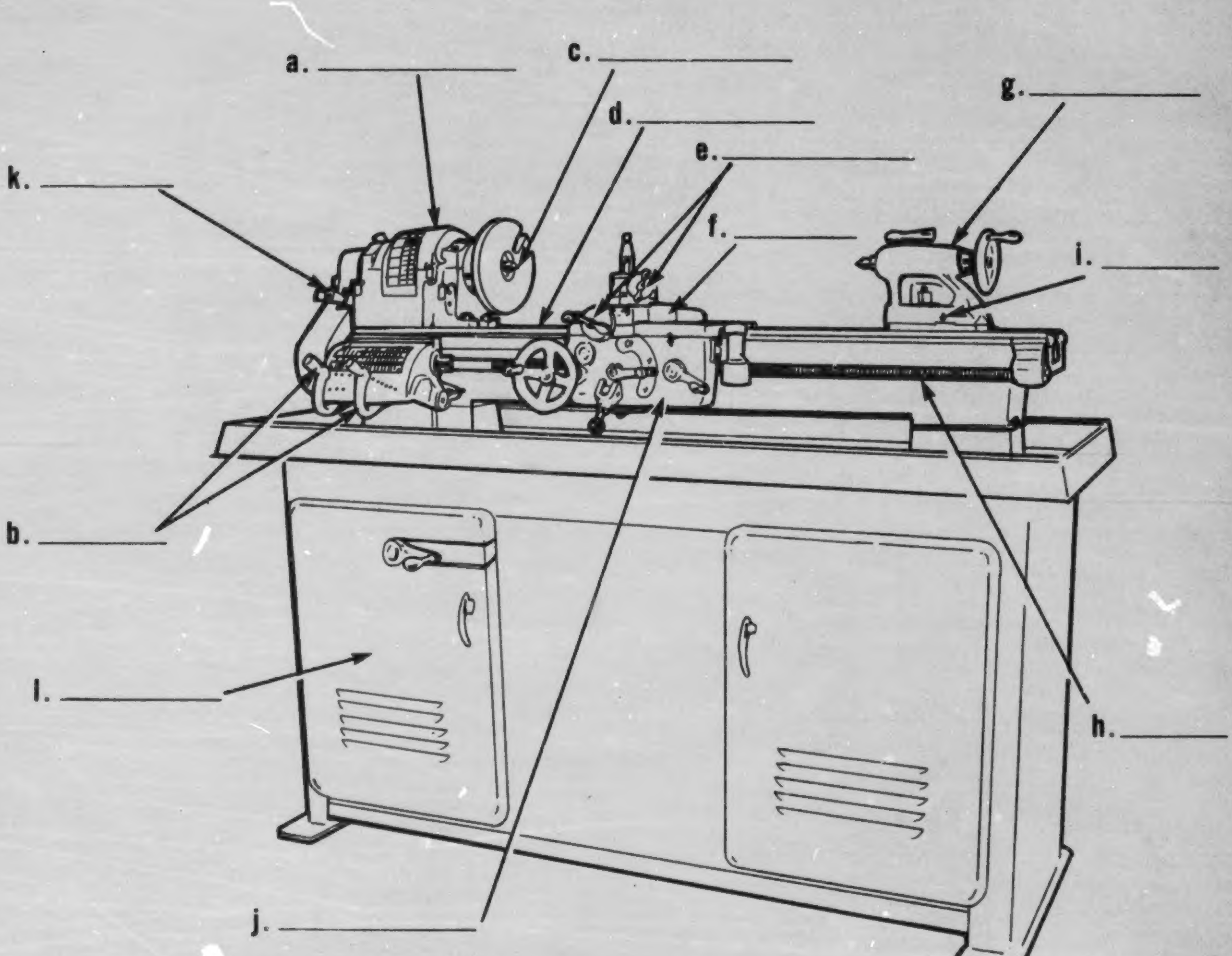
d.



d. ______________________________

3. Identify the main parts of the lathe by writing each of the following names of parts in the spaces provided.

Carriage
Feed reverse lever
Headstock
Spindle
Cross-feed cranks
Lead screw
Compound rest
Bed
Set screw
Screw-feed levers
Tailstock
Motor



4. Select the correct safety rules to be followed when operating a lathe by circling the number of the correct answer.

   a. The proper protective clothing to wear when operating a lathe would include:

      (1) a cap, long-sleeved shirt, and heavy socks.

      (2) a hard hat, knee pads, and soft-soled shoes.

      (3) eye glasses, snug-fitting clothing, and a protective apron or coveralls.

   b. You should operate a lathe

      (1) only after receiving proper instructions.

      (2) when you see others operating the lathes.

      (3) as soon as you can get the tools together.

   c. Make adjustments on the lathe

      (1) only when it is stopped.

      (2) with long-handled tools.

      (3) without stopping the spindle.

   d. Tools and accessories should be placed

      (1) on the ways of the bed.

      (2) on the saddle.

      (3) on a board on the ways or tool rack.

   e. Proper use of the lathe should include:

      (1) keeping guards in place and repair of faulty parts.

      (2) operating the lathe until a faulty part completely breaks.

      (3) starting the lathe without checking for loose parts or control settings.

   f. To avoid horseplay, one should

      (1) Sit to one side of the lathe, unnoticed.

      (2) Leave the lathe to run by itself.

      (3) Not talk to another lathe operator while the lathe is running.

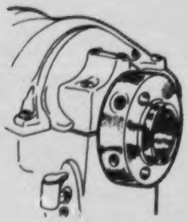
UNIT II

LATHE OPERATIONS

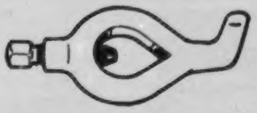
TEST PART 2

1. Identify the accessories available for a lathe headstock by writing each of the following names by the correct illustration.

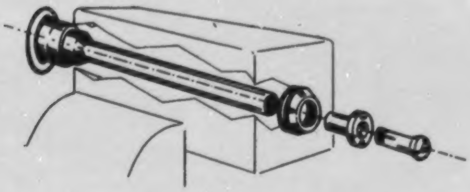
Collets
Lathe dog
Faceplate
Three-jaw universal chuck
Four-jaw independent chuck
Camlock spindle



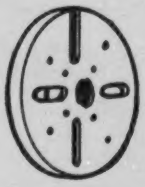
a. ____________________________



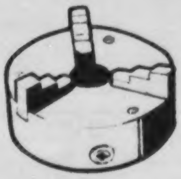
b. ____________________________



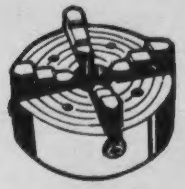
c. ____________________________



d. ____________________________



e. ____________________________

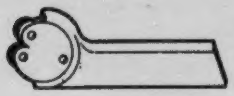


f. ____________________________

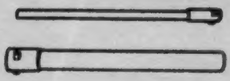
2. Identify the accessories used on the lathe carriage by writing the names listed below by the correct illustration.

Rocker tool post
Follower rest
Taper attachment
Knurling tool
Threading tool
Four-way tool post

Tool post grinder
Right-hand roughing tool
Boring bar
Parting tool
Right-hand offset tool holder
Open-side tool post



a. ______________________________



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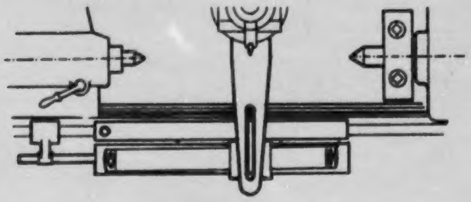
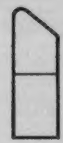
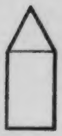


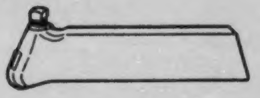
c. ______________________________



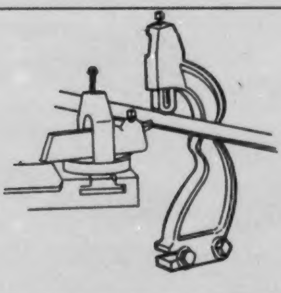
d. ______________________________



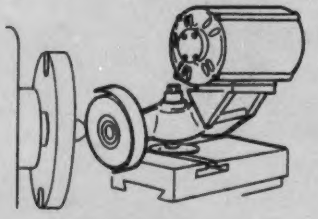
e. ______________________________



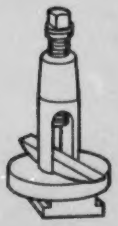
f. ______________________________



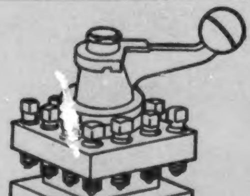
g. ______________________________



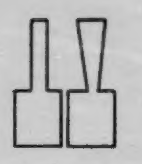
h. ______________________________

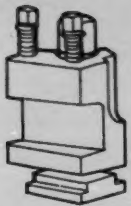


i. ______________________________



j. ______________________________

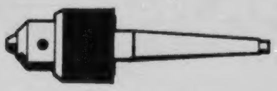


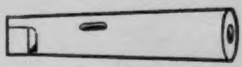


k. ______________________________ l. ______________________________

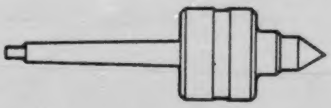
3. Identify the accessories used on a lathe tailstock by writing each of the following names by the correct illustration.

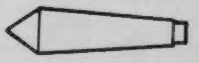
Drill chuck
Ball bearing center
Pipe center
Sleeve
Solid center



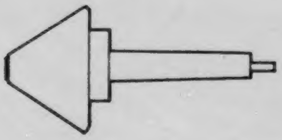


a. ______________________________ b. ______________________________





c. ______________________________ d. ______________________________



e. ______________________________

UNIT II

LATHE OPERATIONS

TEST PART 3

1. Match terms associated with the operation of a lathe to the correct definition by placing the number of each term on the right in the blanks on the left.

____a. The number of times the workpiece rotates in one minute.

____b. Term applied to two parts that must be forced together.

____c. The movement of the carriage along the bed or the cross-slide and compound rest across the carriage.

____d. The distance the tool moves with each revolution of the workpiece.

____e. Aligning a workpiece on the centerline of the spindle of the lathe.

____f. The amount of stock removed in one pass of the cutting tool.

____g. The size called for on a blueprint.

____h. A small groove cut aroung the workpiece with a parting tool.

____i. The speed of the outside edge of the workpiece which is stated in feet per minute.

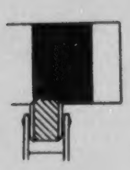
____j. The difference in diameters over a foot in length of a cone-shaped part.

____k. A hard metal used to make cutting tools for the lathe.

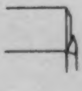
____l. The type of metal the workpiece is made of.

1. Centering
2. Cutting speed
3. Depth of cut
4. Feed
5. Material
6. Pressfit
7. Relief
8. Revolutions per minute
9. Specified
10. Taper per foot
11. Tool steel
12. Travel

2. Identify each of the operations performed on a lathe by writing the correct name of each in the blanks provided.



a. ______________________________



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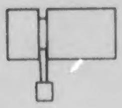

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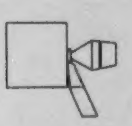

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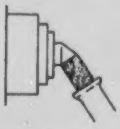

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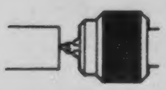

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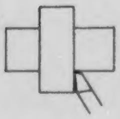

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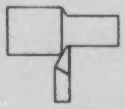

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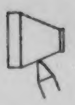

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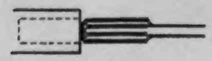

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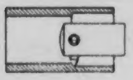

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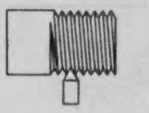


l. ______________________________

3. Point out the things to consider when you are setting feeds or speeds on the lathe by placing a "✓" in front of each.

____a. Type of cutter

____b. Length of bed on lathe

____c. Type of chuck

____d. Finish required

____e. Type of metal

____f. Depth of cut

UNIT II

LATHE OPERATIONS

ANSWERS TO TEST

Part 1

1. Explanation should include:

   a. The engine lathe is a power-driven machine tool which removes metal from a workpiece by rotating the workpiece against a single-point cutting tool.

   b. The engine lathe is capable of performing any operation needed to machine any replacement part on the lathe.

2. a. Tracer
   b. Numerical control
   c. Engine
   d. Automatic
   e. Turret

3. a. Headstock
   b. Screw feed levers
   c. Spindle
   d. Bed
   e. Cross-feed crank
   f. Compound rest
   g. Tailstock
   h. Lead screw
   i. Set screw
   j. Carriage
   k. Feed reverse levers
   l. Motor

4. a. 3
   b. 1
   c. 1
   d. 3
   e. 1
   f. 3

Part 2

1. a. Camlock spindle
   b. Lathe dog
   c. Collets
   d. Faceplate
   e. Three-jaw
   f. Four-jaw

2. a. Knurling tool
   b. Boring bar
   c. Taper attachment
   d. Tool steel
   e. Threading tool
   f. Right-hand offset tool holder
   g. Follower rest
   h. Tool post grinder
   i. Rocket tool post
   j. Four-way tool post
   k. Parting tool
   l. Open-side tool post

3. a. Drill chuck
   b. Sleeve
   c. Ball bearing center
   d. Solid center
   e. Pipe center

Part 3

1. a. 8
   b. 6
   c. 12
   d. 4
   e. 1
   f. 3
   g. 9
   h. 7
   i. 2
   j. 10
   k. 11
   l. 5

2. a. Knurling
   b. Chamfering
   c. Parting
   d. Facing
   e. Grinding
   f. Center drilling
   g. Shoulder turning
   h. Straight turning
   i. Taper turning
   j. Reaming
   k. Boring
   l. Threading

3. a.
   d.
   e.
   f.

UNIT III

MILLING OPERATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to use the correct terminology when identifying the types and parts of the milling machine, the accessories, and cutters used on the milling machine. The student will also be able to select the correct safety practices to follow when performing each of the operations on the milling machine. This knowledge will be evidenced through demonstration and by satisfactorily completing a unit test.

SPECIFIC OBJECTIVE

Upon completion of this unit, the student will be able to:

1. Explain the purpose of a milling machine.
2. Match terms associated with milling operations to the correct definition.
3. Identify the types of milling machines.
4. Identify the parts of a milling machine.
5. Point out the correct safety practices to follow when operating a milling machine.
6. Identify the work holding devices used on the milling machine.
7. Identify the types of milling cutters used on the milling machine.
8. Identify the types of operations performed on the milling machine.
9. Select the correct method of milling.
10. Identify the things to consider when setting feeds and speeds on the milling machine.
11. Figure RPM for the milling machine.
12. Figure indexing for gear cutting.
13. Figure gear tooth depth for cutting gears.
14. Demonstrate the ability to:
    a. Set up for milling in a vise.
    b. Mill a keyway with a vertical mill.
    c. Mill a woodruff keyseat on a vertical mill
    d. Mill a spurgear.

UNIT III

MILLING OPERATIONS

SUGGESTED TEACHING ACTIVITIES

I. Objective sheet

   A. Discuss the unit objective with the students.

   B. Discuss each specific objective with the students.

   C. Have the students complete the objectives in the most logical sequence for shop organization.

   D. Add any objectives necessary.

II. Information and assignment sheets

   A. INFORMATION SHEET 1--INTRODUCTION TO MILLING

      1. Explain the operation of the milling machine.

      2. Discuss the various types of milling machines (Transparency 1).

      3. Identify the parts of the milling machine (Transparencies 2 & 3).

      4. Discuss safety rules that relate to use of the milling machine.

   B. INFORMATION SHEET 2--MILLING ACCESSORIES

      1. Explain the use of accessories for the milling machine (Transparencies 4 & 5).

      2. Discuss the use of the various mill cutters.

      3. Discuss speeds and feeds (Transparencies 6-8).

      4. Discuss the use of the dividing head (Transparency 9).

      5. Identify the parts of the spur gear (Transparency 10).

   C. INFORMATION SHEET 3--OPERATION OF THE MILLING MACHINE

      1. Discuss the various operations performed on the milling machine.

      2. Explain the difference and the uses of conventional and climb milling.

      3. Discuss the considerations when selecting and figuring speeds and feeds (Transparencies 6-8).

4. Use the following assignment sheets to reinforce this area of information:

   a. ASSIGNMENT SHEET 1--FIGURING RPM

      (1) Assist the students with the problems.

      (2) Explain the importance of using correct speeds and feeds.

   b. ASSIGNMENT SHEET 2--FIGURING INDEXING GEAR CUTTING

      (1) Assist the students with the calculations.

      (2) Show the students how to apply the problems on the dividing head.

   c. ASSIGNMENT SHEET 3--FIGURING GEAR TOOTH DEPTH

      (1) Assist the students with the spur gear problems.

      (2) Show Transparency 10 so students may refer to the parts of the spur gear.

      (3) Explain how the problems relate to cutting a spur gear.

III. Transparency masters

(NOTE: Transparencies are provided in the student manuals as information sheets.)

A. TM-1--TYPES OF MILLING MACHINES

B. TM-2--PARTS OF A HORIZONTAL MILLING MACHINE

C. TM-3--PARTS OF A VERTICAL MILLING MACHINE

D. TM-4--TYPES OF VISES

E. TM-5--A TYPICAL SCREWJACK, CLAMP, AND BLOCK SET-UP

F. TM-6--FEEDS FOR HIGH SPEED STEEL MILL CUTTERS

G. TM-7--RPM FOR HIGH SPEED STEEL CUTTERS

H. TM-8--CUTTING SPEEDS

I. TM-9--PARTS OF A DIVIDING HEAD

J. TM-10--PARTS OF A SPUR GEAR

IV. Job sheets

A. JOB SHEET 1--SETUP FOR MILLING IN A VISE

1. Discuss the safety precautions for the milling machine.

2. Demonstrate the operation of the milling machine.

3. Demonstrate the alignment of the vise and workpiece.

B. JOB SHEET 2--MILL A KEYWAY WITH A VERTICAL MILL

1. Provide students with a workpiece and blueprint or sketch to work from.

2. Demonstrate the procedures.

3. Reinforce the need for correct speeds and feed.

C. JOB SHEET 3--MILL A WOODRUFF KEY SEAT ON A VERTICAL MILL

1. Provide students with a workpiece and a blueprint or sketch of the keyseat location.

2. Demonstrate the correct setup and procedures.

D. JOB SHEET 4--MILL A SPUR GEAR

1. Have students to produce a spur gear blank and mandrel as lathe projects.

2. Assist students with pressing the blank onto the mandrel.

3. Assist the students with the figuring for the dividing head ratio and tooth depth.

4. Demonstrate the proper setup and cutting procedures.

IV. Answers to assignments

A. Discuss the correct answers with the students.

B. Explain the use of machinist manuals in figuring similar problems.

C. Relate the problems to industrial operations.

V. Unit test

A. The unit test is divided into three parts.

(NOTE: Each part covers one information sheet.)

B. Various approaches may be used in testing:

   1. Each part of the test may be given as the students reviews the information on each information sheet.

   2. Give the entire test upon completion of all information sheets in the unit.

   3. Give one or more parts of the test as an additional assignment, or to reinforce areas the student did not understand.

VI. Answers to the test

A. Answers are based on total information presented in the unit.

B. For convenience of grading, add corresponding answer sheets for additional test parts.

VII. References

A. Weingartner, C. Machinist Ready Reference. Prakken Publications, Inc. Ann Arbor, Michigan 48107

B. A Suggested Basic Course Outline for General Metal Trades Cluster. Occupational Curriculum Laboratory, East Texas State University, Commerce, Texas 75425

C. Walker, John R. Machining Fundamentals. The Goodheart-Wilcox Co., Inc. South Holland, Illinois 1969

D. Walker, John C. Modern Metalworking. The Goodheart-Wilcox Co., Inc. South Holland, Illinois 1976

UNIT III

MILLING OPERATIONS

INFORMATION SHEET 1--INTRODUCTION TO MILLING

I. Operation of the milling machine

A. The milling machine removes metal from a workpiece which is fed into a multi-toothed cutter.

B. The milling machine is used to cut flat and uneven surfaces; to drill and bore; to cut gears that are spiral; and to cut slots.

II. Terms and definitions

A. Arbor--a shaft or spindle on the milling machine that holds milling cutters.

B. Axis--the centerline of a workpiece or stock.

C. Circumference--the length of a curved outside edge of a round part.

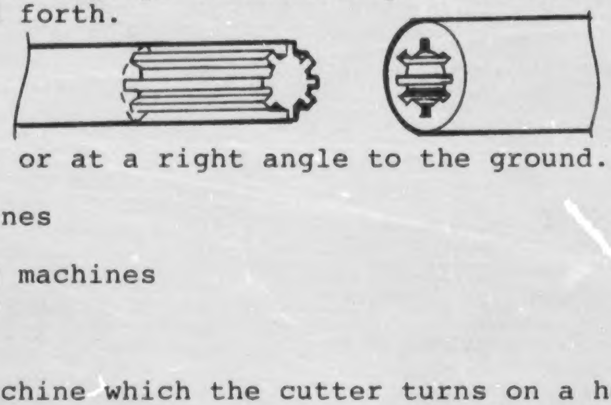
D. Horizontal--parallel to the ground.

E. Indexing--the process of dividing a round or any other shape of workpiece into equal divisions, using the dividing head.

F. Safety zone--the line or area that indicates a safe distance from a cutter or machine.

G. Spiral--something which winds around a round object (e.g., a column or shaft) as it moves along the object.

H. Splines--a key or group of keys on a mechanical shaft that fit into a keyway or keyways in another part so that they can slide back and forth.



I. Vertical--upright, or at a right angle to the ground.

III. Types of milling machines

A. Horizontal milling machines

1. Plain

a. Milling machine which the cutter turns on a horizontal axis.

(NOTE: This machine can be changed to a vertical milling machine with a special attachment.)

b. Table has the three basic movements (vertical, cross traverse, and long longitudinal).

2. Universal

a. Similiar to the plain milling machine except the table will also swivel on the saddle of the machine.

b. This feature allows spiral gears, splines, and other helical work to be produced.

B. Vertical milling machine

1. Has a vertical axis which holds and turns the cutter.

2. Is used mainly for operations which call for the use of end mill or face mill cutters.

IV. Parts of a milling machine

A. Column--provides the support and alignment for the rest of the machine parts.

(NOTE: Ways are ground into the column to provide the alignment.)

B. Base--provides the floor support for the column.

C. Knee--the large part in front of the machine which provides support for the saddle and bed and houses most of the controls for movement of the bed.

D. Saddle--sits on the ways of the knee and moves the table to and away from the column.

(NOTE: Ways are ground into the saddle for the table to slip on.)

E. Table--travels to the right and left and provides a working surface for the workpiece and attachments.

(NOTE: Tables on the universal horizontal milling machine will also swivel to about 45°.)

F. Overarm--provides support for the arbor and also supports the motor assembly on vertical machines.

G. Feed selector--controls the feed rate of the table and workpiece in inches per minute.

(NOTE: The feed is usually separate from the speed of the spindle.)

H. Spindle--holds and turns the cutting tools in the milling machine.

(NOTE: The speed of the spindle is controlled by variable speed controls on the motor.)

I. Arbor--holds the cutting tool on a horizontal milling machine.

J. Motor assembly--provides the power source for turning the spindle.

(NOTE: Most motors have a speed range selector and a variable speed control to control the spindle speed.)

V. Milling machine safety practices

A. Wear approved safety goggles or face shield at all times.

B. Clean and dry the table before mounting accessories.

C. Be sure the accessories are securely fastened to the table.

D. Check the workpiece to see that it is securely mounted.

E. Select the proper cutter and make sure it is rotating in the proper direction.

(NOTE: See Methods of Milling in Information Sheet

F. Be sure the arbor, cutter, or collars are clean before mounting them on the machine.

G. Use a rag to handle sharp cutters.

H. Keep fingers clear of the arbor hole when sliding the overarm in place.

(NOTE: Be sure the overarm is secured.)

I. Use correct fitting wrenches on the machine.

J. Tighten the arbor nut by hand tightening with a wrench--never use power for tightening.

K. Make adjustments with the machine stopped.

L. Always use the correct spindle speed, proper feed, and the correct depth of cut.

M. Use a soft-headed hammer to seat the workpiece in the vise.

N. Make sure that the table, work holding device, and workpiece will clear the arbor and arbor support during the cut.

O. Disengage the feed handwheels and handles when power feed is to be used.

P. Loosen the table, knee, and saddle clamps when making adjustments.

(NOTE: When adjustments have been made, tighten the clamps on the slides which should not move during the operation.)

Q. Make sure that unauthorized persons are not in the safety zone around the machine when the machine is started.

R. Stay clear of a revolving cutter and never reach over the cutter.

S. Stop the cutter to remove chips and then use a brush.

T. Check to be sure all power feed controls are stopped when the operation is completed.

U. Keep the floor area around the machine free of oil and chips.

V. Always clean the machine with a brush first and then a rag.

W. Always use hand feeding when moving the work up to the cutter--never use the power feed.

X. Always turn OFF the power to your machine if you must leave it, even for just a minute or two.

UNIT III

MILLING OPERATIONS

INFORMATION SHEET 2--MILLING ACCESSORIES

I. Work holding devices

  A. Vises--clamped to the mill table to hold workpiece

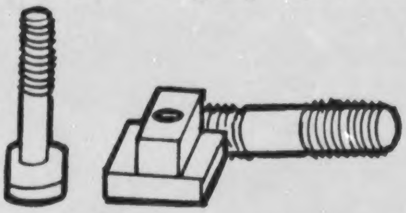
    1. Plain

    2. Swivel

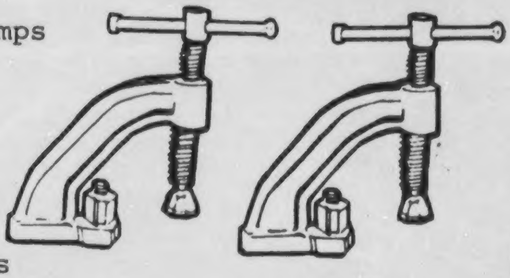
    3. Universal

  B. Clamping accessories--used to clamp work directly to the mill table.

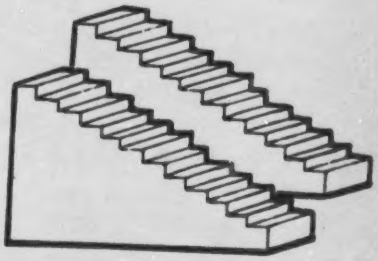
    1. T-slot bolts



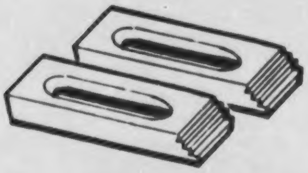
    2. T-slot clamps

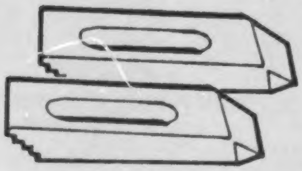


    3. Step blocks

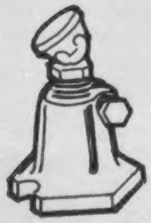


    4. Strap blocks



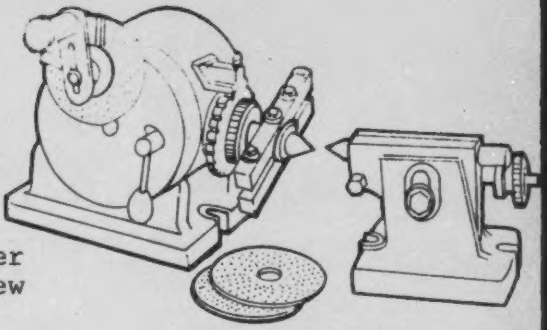


    5. Screw jack



C. Other accessories

1. Dividing head



a. Use to turn a workpiece at a specified rate or in equal divisions during a milling operation.

b. Turned by hand or power feed from the leadscrew through a gear train.

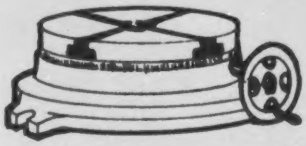
c. Holds the workpiece in a horizontal or vertical position.

(NOTE: A chuck is often used in place of the center when positioned vertically.)

d. The spindle turns one turn for every 40 turns of the hand crank.

(NOTE: This provides a gear ratio of 40:1.)

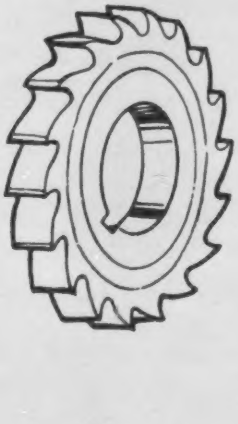
2. Rotary table



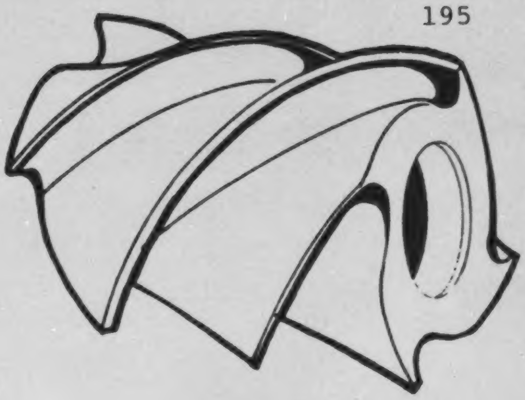
a. Use to turn a workpiece for cutting a radius or performing milling operations at different locations at specified degree or location.

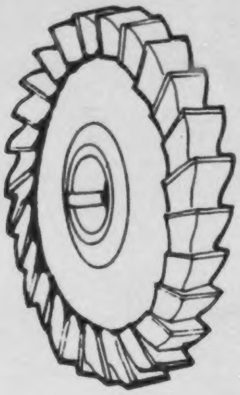
b. The table is graduated in degrees and the hand wheel is graduated in minutes.

II. A. Plain mill cutter--a round cutting tool with teeth on the circumference.



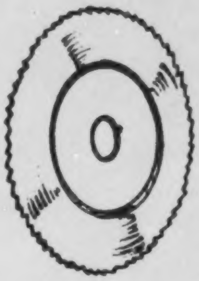
B. Helical plain mill cutter--a cutting tool with a curved cutting edge that is used to take wide shallow cuts on soft metals.

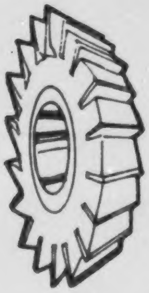




C. Side mill cutter--a cutting tool with teeth on the side as well as the circumference.

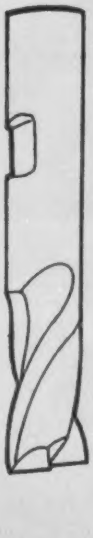
D. Metal slitting saw--A cutting tool used to cut narrow slots or for cutoff operations.





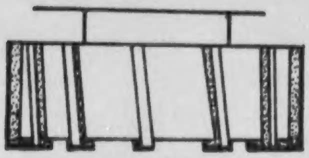
E. Angle mill cutter--a cutting tool used to cut angle cuts such as V-notches, V-grooves, dovetails, and reamer teeth.

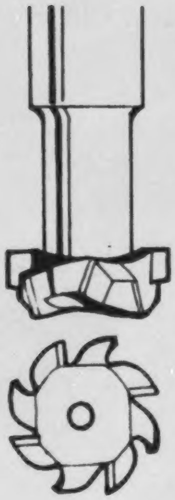
F. End-mill cutter--a cutting tool used to cut slots, keyways, flat surfaces, and shoulders.



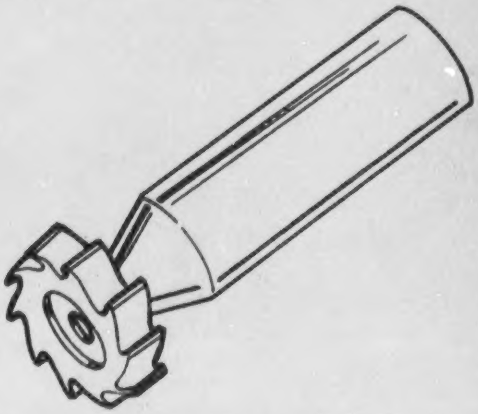
G. Face-mill cutter--a cutting tool used to mill large flat surfaces.

(NOTE: Face-mill cutters are over 6 inches in diameter and shell end-mill cutters are under 6 inches in diameter.)

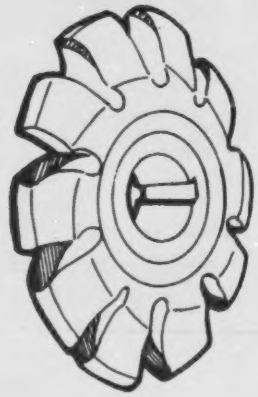




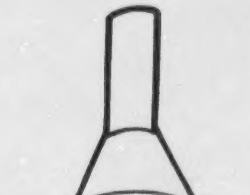
H. T-slot mill cutter--an end-mill cutter designed to cut T-shaped slots.



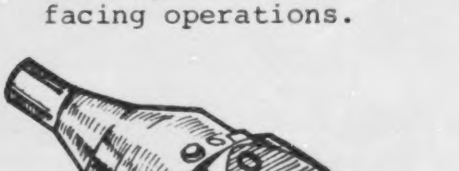
I. Key-seat cutter--an end-mill cutter used to cut woodruff or half-moon key seats.



J. Formed-tooth cutter--A cutting tool used to cut irregular shapes such as a radius, gear tooth, convex, or concave surface.



K. Flycutter--A single point cutting tool used for facing operations.



L. Boring bar--A cutting tool to bore holes or cut internal surfaces such as cylinders on engine blocks.

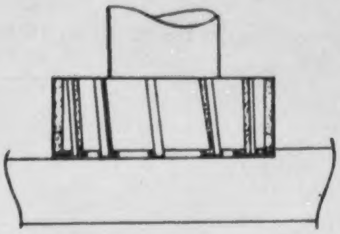
UNIT III

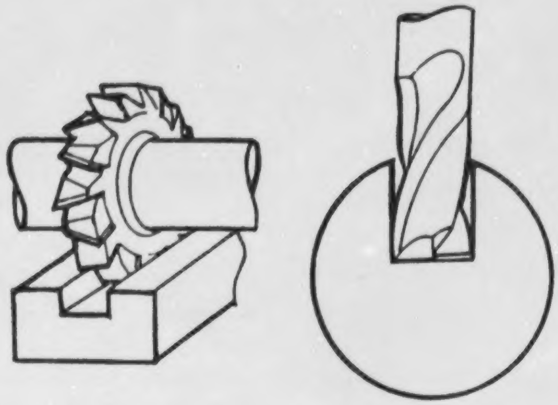
MILLING OPERATIONS

INFORMATION SHEET 3--OPERATION OF THE MILLING MACHINE

I. Types of operations

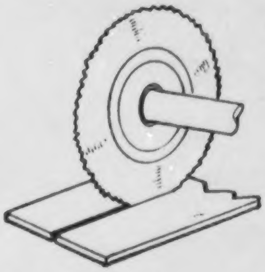
A. Facing--machining a flat surface with a shell end mill or end mill cutter.

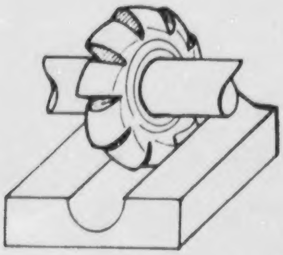




B. Groove or keyway cutting--cutting a slot in a flat or round workpiece with a plain mill or end mill cutter.

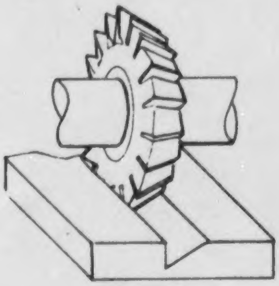
C. Slitting or cutoff--cutting a workpiece into or a deep slot in a workpiece.



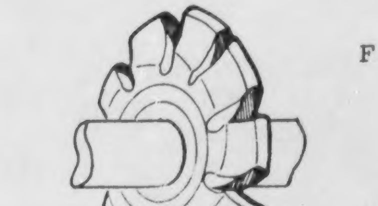


D. Form cutting--cutting a radius, convex, or concave surface.

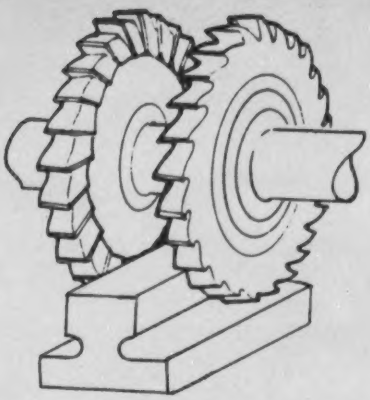
E. Angle cutting--cutting a single or double angle on a surface.

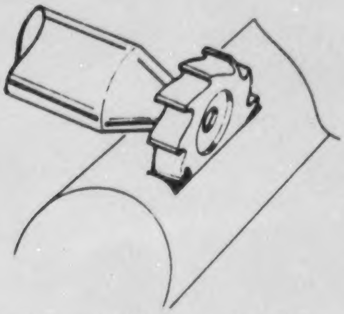


F. Gear cutting--cutting gear teeth on a workpiece or casting.



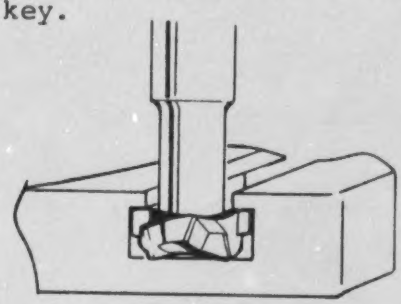
G. Straddle milling--cutting two sides of a workpiece with one pass, using side mill cutters.

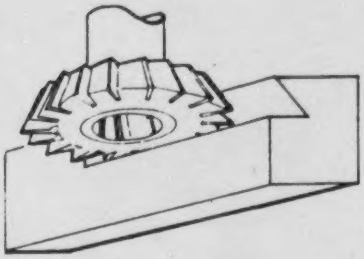




H. Woodruff keyseat cutting--cutting a slot for a half-moon key.

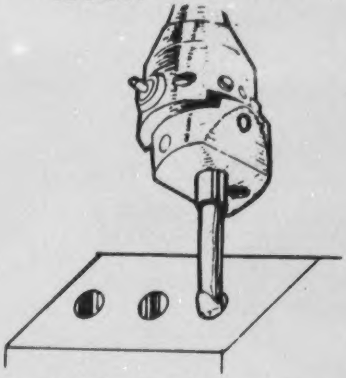
I. T-slot cutting--cutting a T-shaped groove for T-slot bolts and other hold down fixtures.





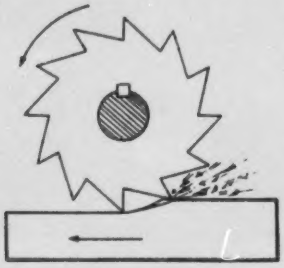
J. Dovetail cutting--cutting an internal V-shaped groove which is used for slides on machine tools.

K. Boring--cutting internal surfaces with a single point cutting tool.



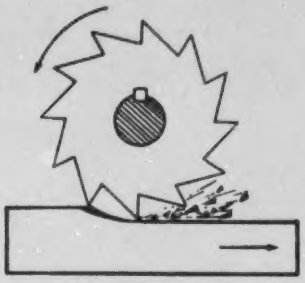
II. Methods of milling

A. Conventional milling--the workpiece is moving into the rotation of the cutter.



(NOTE: This is the safest and most commonly used method.)

B. Climb milling--the workpiece and cutter are moving the same direction.



(NOTE: This method can only be used on new machines or those designed for climb milling.)

III. Things to consider when setting feeds and speeds.

A. Type of metal being machined.

EXAMPLES: Mild steel, brass, aluminum, tool steel.

(NOTE: This will be used to select the cutting speed and figure RPM.)

B. Hardness of metal being machined.

C. Type of cutting tool being used.

EXAMPLES: High speed steel, carbon steel, carbide.

D. Type of cutter being used.

(NOTE: Cutters will vary by diameter, number of teeth, and cutting angle.)

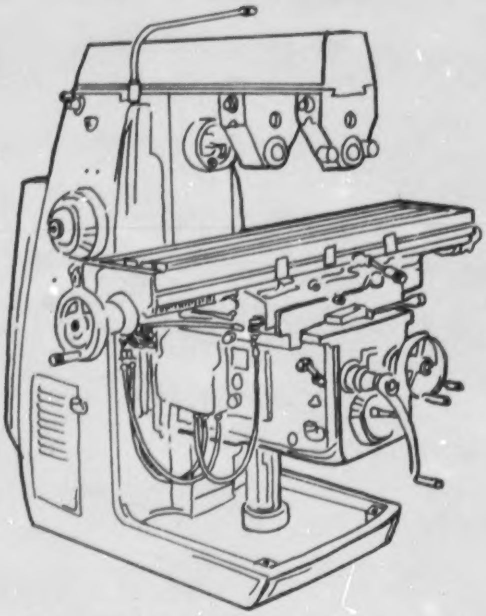
E. Amount of material being removed.

1. Roughing cuts

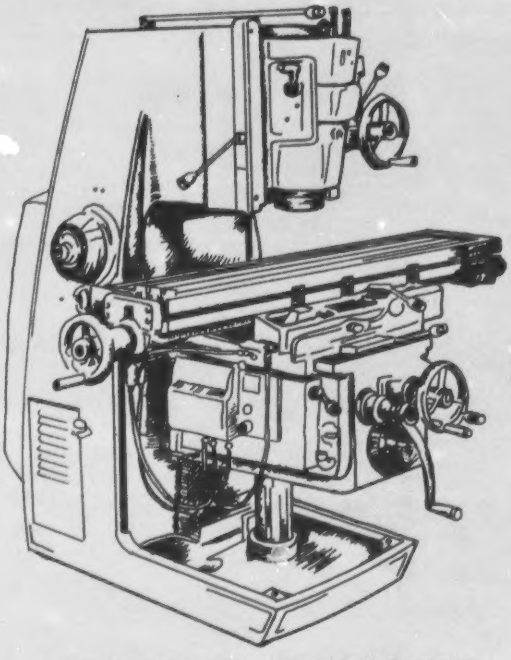
2. Finishing cuts

F. If a coolant is being used.

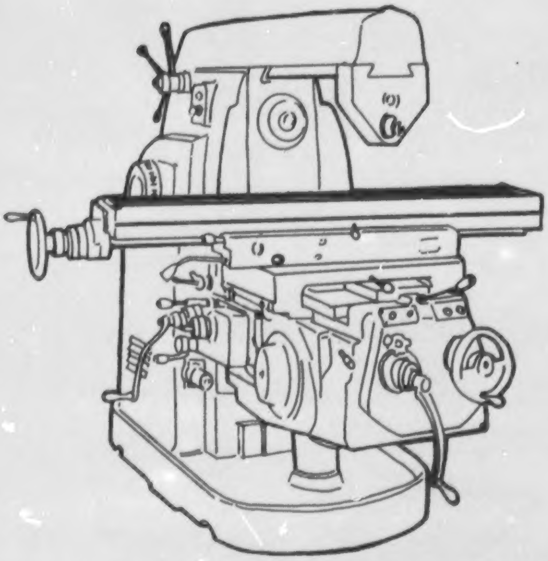
TYPES OF MILLING MACHINES



PLAIN MILLING MACHINE

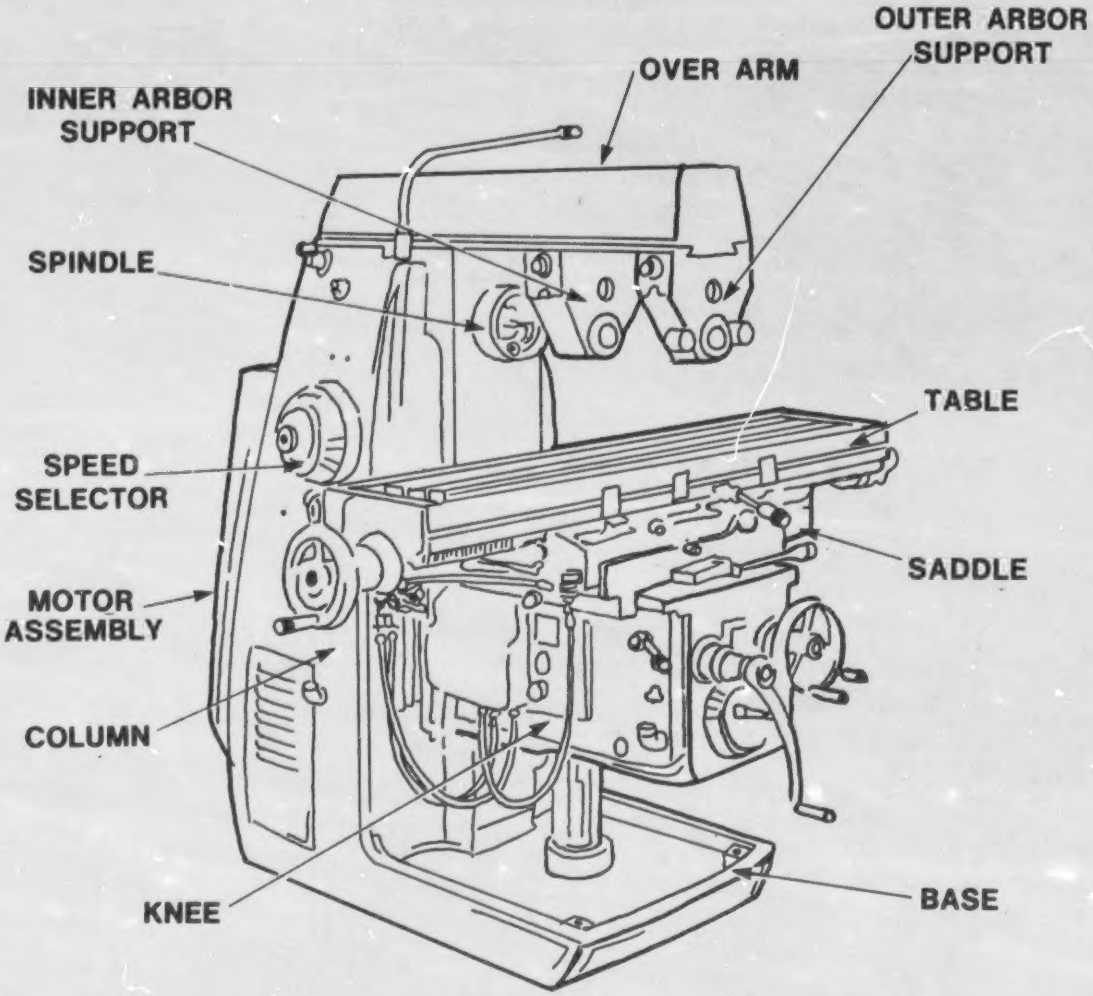


VERTICAL MILLING MACHINE

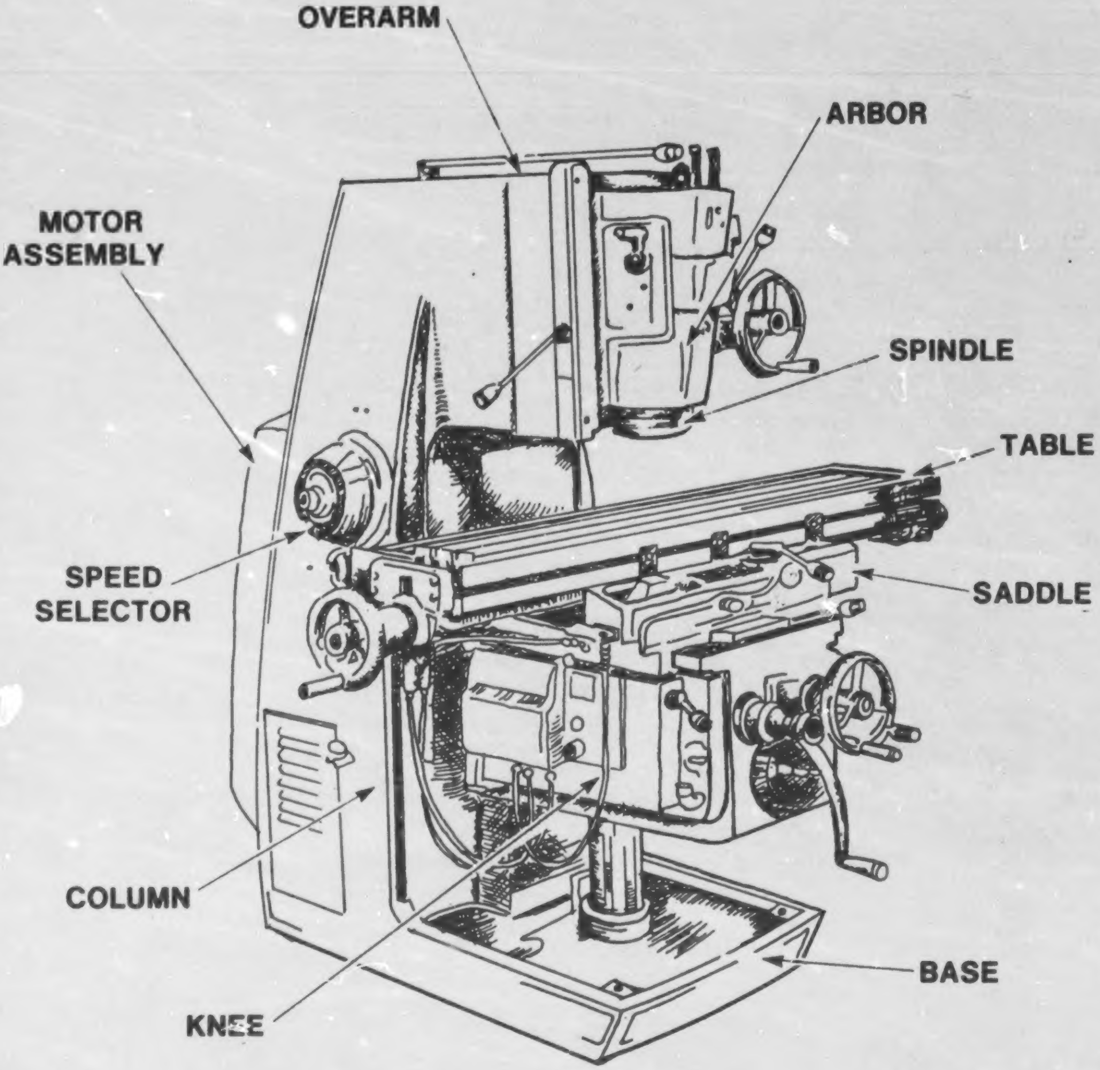


UNIVERSAL MILLING MACHINE

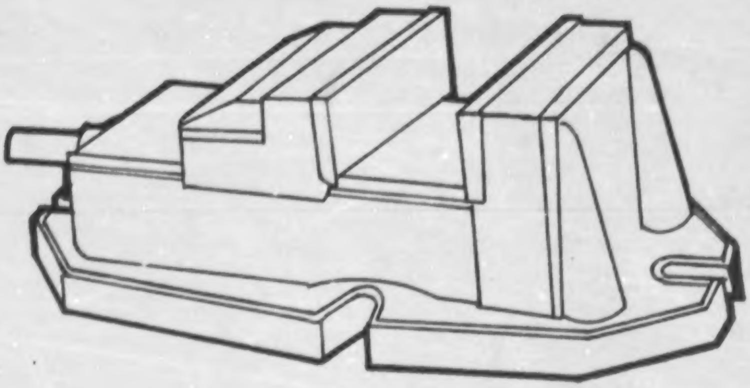
PARTS OF A HORIZONTAL MILLING MACHINE


OUTER ARBOR SUPPORT
OVER ARM
INNER ARBOR SUPPORT
SPINDLE
TABLE
SPEED SELECTOR
SADDLE
MOTOR ASSEMBLY
COLUMN
KNEE
BASE

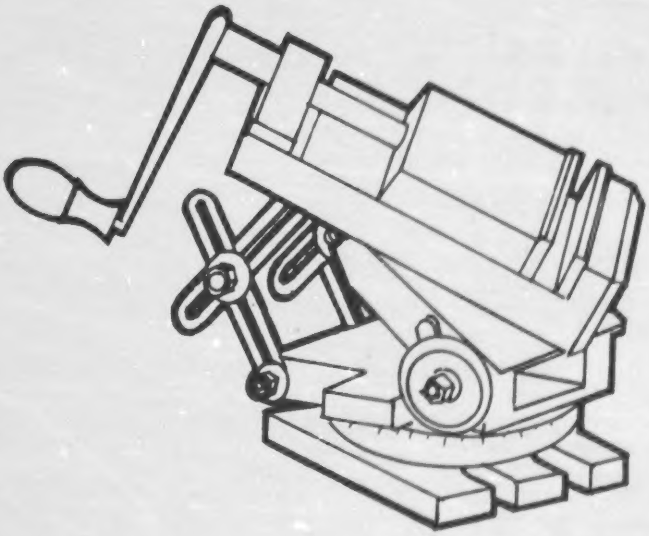
PARTS OF A VERTICAL MILLING MACHINE


OVERARM
ARBOR
MOTOR ASSEMBLY
SPINDLE
TABLE
SPEED SELECTOR
SADDLE
COLUMN
BASE
KNEE

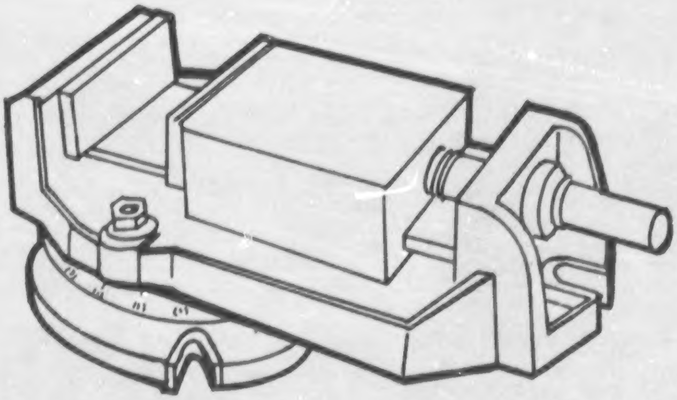
TYPES OF VISES



PLAIN VISE

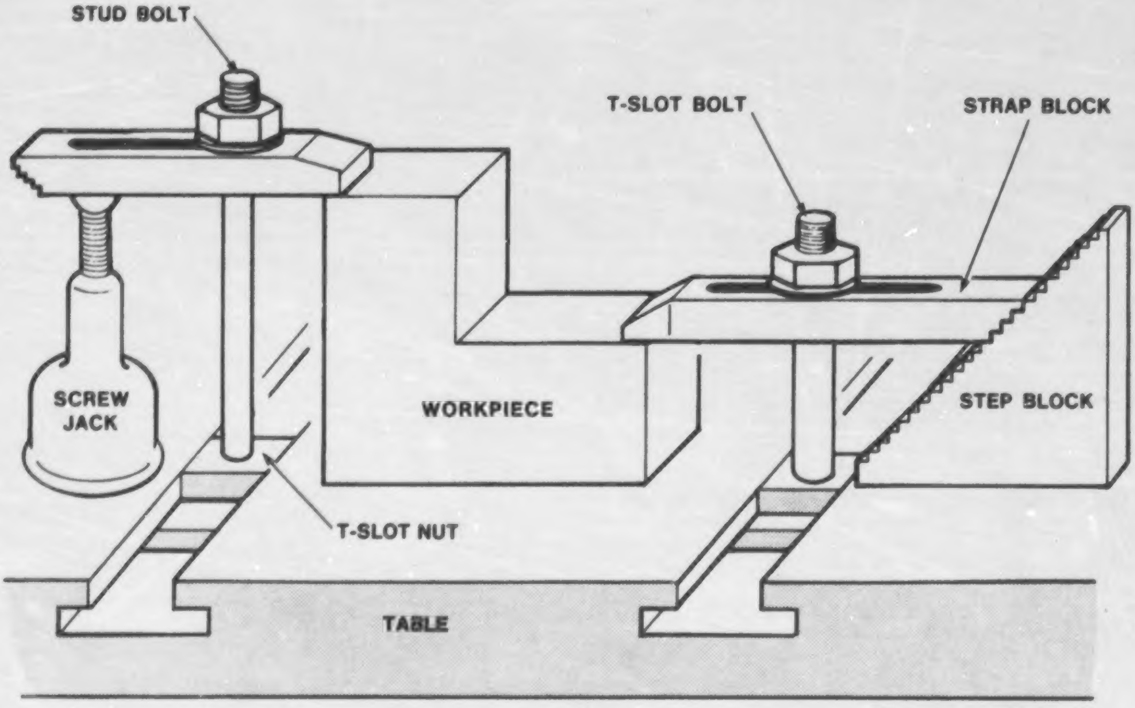


UNIVERSAL VISE



SWIVEL VISE

A TYPICAL SCREW JACK, CLAMP, AND BLOCK SET-UP


STUD BOLT
T-SLOT BOLT
STRAP BLOCK
SCREW JACK
WORKPIECE
STEP BLOCK
T-SLOT NUT
TABLE

FEEDS FOR HIGH SPEED STEEL MILL CUTTERS

MATERIAL	*CUTTERS*					
	FACE MILLS	SPIRAL MILLS	SLOTTING & SIDE MILLS	END MILLS	FORM CUTTERS	SAWS
Aluminum and soft bronze...	.022	.017	.013	.011	.006	.005
Medium bronze and soft cast iron...............	.018	.014	.011	.009	.005	.004
Malleable iron and medium cast iron...............	.015	.012	.009	.008	.005	.004
SAE X-1112 steel and hard cast iron...............	.013	.010	.008	.006	.004	.003
SAE 1020 steel and SAE X-1335 steel.........	.011	.009	.007	.005	.004	.003
SAE 1045 steel and cast steel....................	.009	.007	.006	.005	.003	.003
Alloy steel, medium........	.008	.006	.005	.004	.003	.002
Alloy steel, tough.........	.007	.005	.004	.004	.002	.002
Alloy steel, 250-300 Brinell..................	.006	.005	.004	.003	.002	.0015
Alloy steel, hard--300-360 Brinell..................	.005	.004	.003	.003	.002	.0015

(Source: AMERICAN MACHINIST)

RPM FOR HIGH SPEED STEEL CUTTERS

DIAMETER OF CUTTER (in inches)	CUTTING SPEEDS IN FEET PER MINUTE						
	40	50	60	70	80	90	100
	Revolutions per Minute						
1/4	611	764	917	1,070	1,222	1,375	1,528
5/16	489	611	733	856	978	1,100	1,222
3/8	407	509	611	713	815	917	1,019
7/16	349	437	524	611	698	786	873
1/2	306	382	458	535	611	688	764
5/8	244	306	367	428	489	550	611
3/4	204	255	306	357	407	458	509
7/8	175	218	262	306	349	393	437
1	153	191	229	267	306	344	382
1 1/8	136	170	204	238	272	306	340
1 1/4	122	153	183	214	244	275	306
1 3/8	111	139	167	194	222	250	278
1 1/2	102	127	153	178	204	229	255
1 5/8	94	117	141	165	188	212	235
1 3/4	87	109	131	153	175	196	218
1 7/8	81	102	122	143	163	183	204
2	76	95	115	134	153	172	191
2 1/4	68	85	102	119	136	153	170
2 1/2	61	76	92	107	122	137	152
2 3/4	56	69	83	97	111	125	139
3	51	64	76	89	102	115	127
3 1/2	44	55	65	76	87	98	108
4	38	48	57	67	76	86	95
4 1/2	34	42	51	59	68	77	85
5	31	38	46	54	61	69	76
5 1/2	28	35	42	49	56	63	70

(Source: AMERICAN MACHINIST)

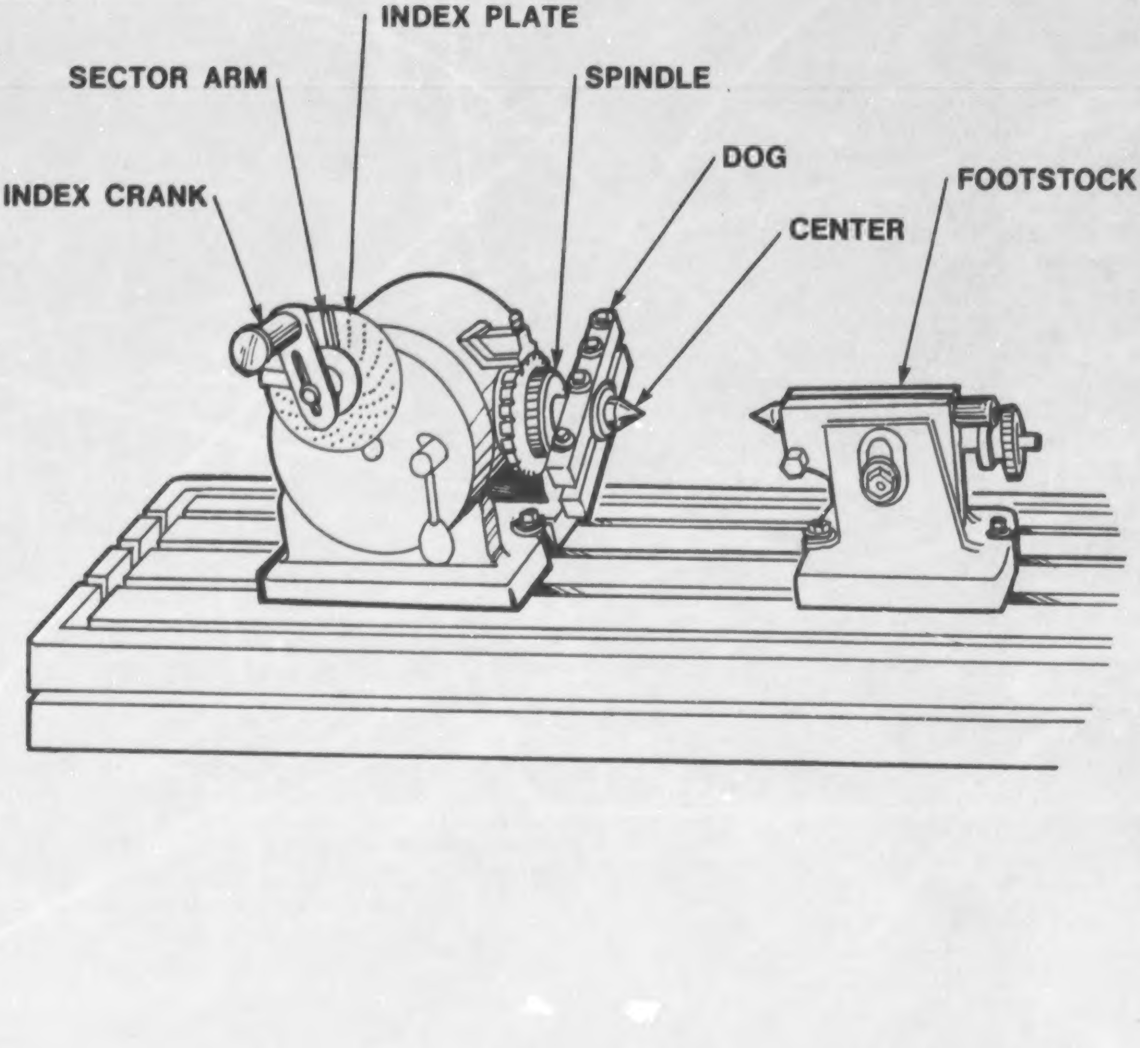
CUTTING SPEEDS

In Surface Feet Per Minute

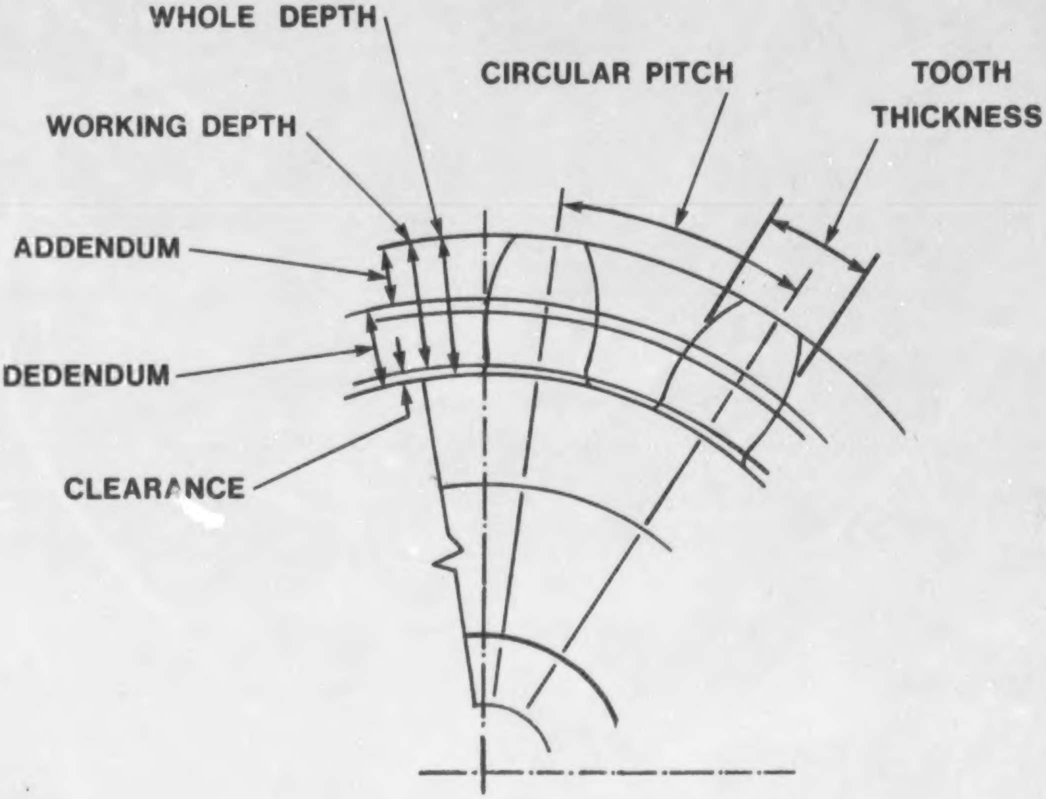
MATERIAL	*CUTTER TYPE*			
	High-Speed Steel		Carbide-Tipped	
	Rough	Finish	Rough	Finish
Cast iron......	50-60	80-110	180-200	350-400
Semisteel......	40-50	65-90	140-160	250-300
Malleable iron.	80-100	100-130	250-300	400-500
Cast steel.....	45-60	70-90	150-180	200-250
Copper.........	100-150	150-200	600	1,000
Brass..........	200-300	200-300	600-1,000	600-1,000
Bronze.........	100-150	150-180	600	1,000
Aluminum.......	400	700	800	1,000
Magnesium......	600-800	1,000-1,500	1,000-1,500	1,000-5,000
SAE steels				
1020 (coarse feed).......	60-80	60-80	300	300
1020 (fine feed)	100-120	100-120	450	450
1035...........	75-90	90-120	250	250
1050...........	60-80	100	200	200
2315...........	90-110	90-110	300	300
3150...........	50-60	70-90	200	200
4340...........	40-50	60-70	200	200
Stainless steel	100-120	100-120	240-300	240-300

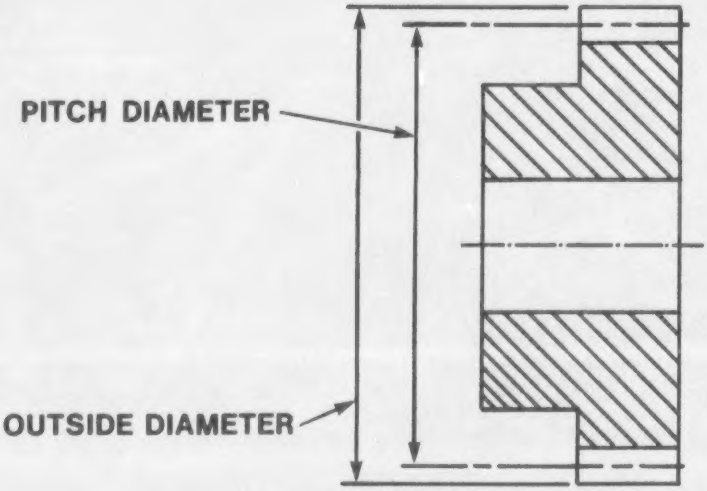
(Source: AMERICAN MACHINIST)

PARTS OF A DIVIDING HEAD


INDEX PLATE
SECTOR ARM
SPINDLE
DOG
INDEX CRANK
FOOTSTOCK
CENTER

PARTS OF A SPUR GEAR


WHOLE DEPTH
CIRCULAR PITCH
TOOTH THICKNESS
WORKING DEPTH
ADDENDUM
DEDENDUM
CLEARANCE


PITCH DIAMETER
OUTSIDE DIAMETER

UNIT III

MILLING OPERATIONS

ASSIGNMENT SHEET 1--FIGURING RPM

DIRECTIONS: Figure the correct speeds to use in each situation below. Show your work. Refer to TM-7 and TM-8.

A. What RPM should be set when rough cutting malleable iron with high speed steel cutter that is 3 inches in diameter.

B. What RPM should be set when finish cutting cast steel with a high speed steel cutter 3/4" in diameter.

C. Using the formula $\frac{4 \times CS}{\text{diameter of cutter}}$ figure the RPM to be set when rough cutting aluminum with a 5-inch diameter cutter made of high speed steel.

D. Using the formula $\frac{4 \times CS}{\text{diameter of cutter}}$ figure the RPM to be set when finish cutting malleable iron with a 3-inch carbide tipped face mill cutter.

UNIT III

MILLING OPERATIONS

ASSIGNMENT SHEET 2--FIGURING INDEXING GEAR CUTTING

DIRECTIONS: The dividing sheet has a ratio of 40 to 1. This means that for every 40 turns of the index crank, the spindle turns one revolution. To determine the number of turns of the index crank for each tooth when gear cutting, divide 40 by the number of teeth to be cut on the gear. Then decide which index plate will work for the situation.

EXAMPLE: To figure turns of the crank for a gear which is to have 28 teeth. Divide 40 by 28.

$$40 \div 28 = 1\ 3/7 \text{ turns}$$

To be able to rotate the index crank 1 3/7 turns, an index plate with a hole pattern that can be divided by 7 must be selected.

EXAMPLES: 21, 28, 35, 42

If the 21-hole pattern was used, the crank would be turned 1 9/21 turns, or one full turn and then 9 of the 21 holes.

A. How many turns would the index crank be turned for each tooth of a gear with 21 teeth? Also, circle the plate hole pattern that would be selected from 21, 23, 27, 29, 31, and 33 hole patterns.

Turns _____ 21 23 27 29 31 33

B. How many turns would the index crank be turned for each tooth of a gear with 13 teeth? Also, circle the plate hole pattern that would be selected from 37, 39, 41, 43, 47, and 49 hole patterns?

Turns _____ 37 39 41 43 47 49

C. How many turns would the index crank be turned for each tooth of a gear with 11 teeth. Also circle the plate hole pattern that would be selected from 21, 23, 27, 29, 31, and 33 hole patterns.

Turns _____ 21 23 27 29 31 33

UNIT III

MILLING OPERATIONS

ASSIGNMENT SHEET 3--FIGURING GEAR TOOTH DEPTH

DIRECTIONS: Figure the depth to cut a gear tooth for each of the following situations. Use the formula--whole depth (ht) = $\frac{2.157}{P}$. Diametrical pitch (P) is usually found on the gear cutter to be used or written on the blueprint.

A. What would the depth of cut be for a 3-inch spur gear that will be milled with a cutter that has a diametrical pitch of 3 1/2?

B. What would be the depth of cut for a 4-inch spur gear that would be milled with a cutter that has a diametrical pitch of 6?

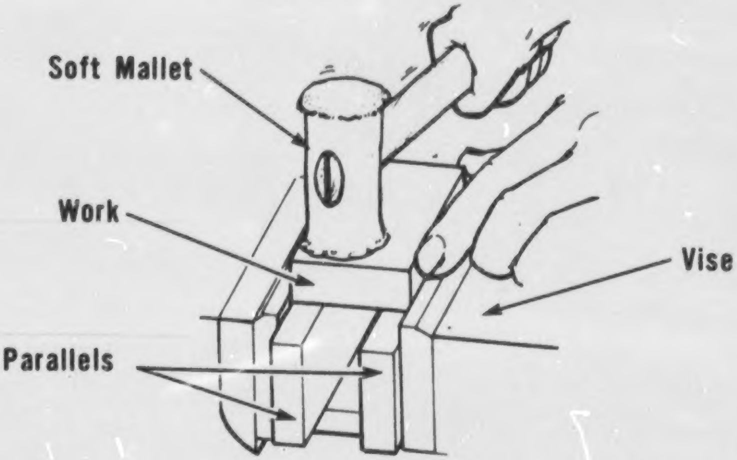
C. What would be the whole depth of a gear tooth for a 6-inch diameter gear with a diametrical pitch of 2 3/4?

D. Align the workpiece in the vise.

1. Select two parallel bars that will provide the correct height for the workpiece.

2. Place the workpiece in the vise with the parallels on each side of the vise.

   (NOTE: Make sure the surfaces of the vise and workpiece are wiped clean.)



3. Tap the work down on the parallels with a leather mallet.

4. Tighten the vise snugly and tap the workpiece solidly down on the parallels.

5. Tighten the vise securely.

6. Remove the vise handle and other tools from the bed.

E. Install the cutter

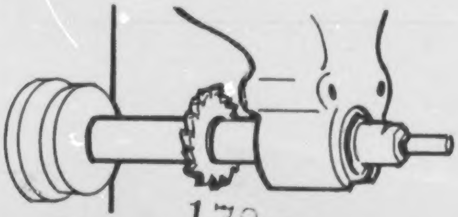
1. Select the correct cutter for the operation required.

   (NOTE: There are various shapes and sizes of cutters for both horizontal and vertical milling machines.)

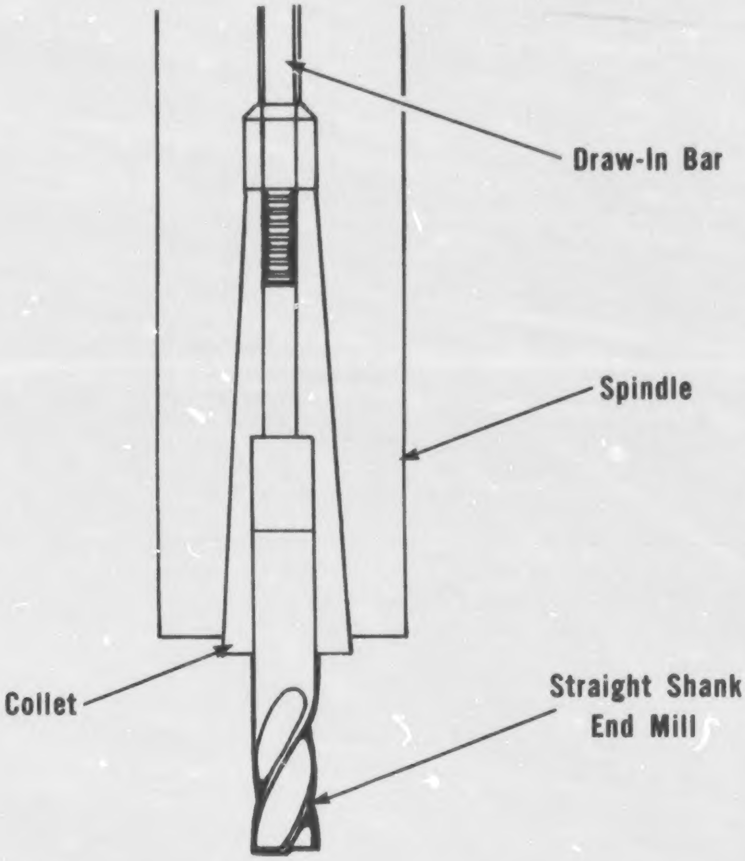
   CAUTION: Handle shop cutters with a shop rag.

2. Install the arbor or cutter holder.

   a. On the horizontal mill, position the cutter on the arbor with spacing collars.



b. On the vertical mill, secure the cutter in the collet and holder by tightening the draw bar.


Draw-In Bar
Spindle
Collet
Straight Shank End Mill

F. Set the RPM

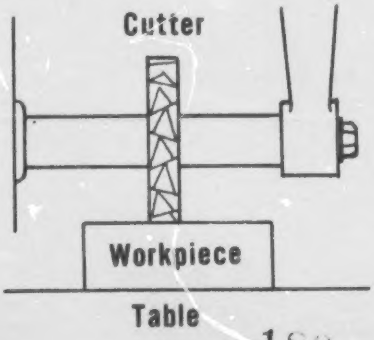
(NOTE: The RPM will depend on the size and type of cutter and the metal being machined.)

G. Zero the mill cutter.

1. Position the mill cutter above the workpiece.

2. Start the machine.

3. Raise the table very slowly until the cutter lightly scratches the surface of the workpiece.


Cutter
Workpiece
Table

UNIT III

MILLING OPERATIONS

JOB SHEET 2--MILL A KEYWAY WITH A VERTICAL MILL

I. Tools and equipment

- A. Swivel mill vise
- B. Dial indicator
- C. T-slot cleaner
- D. Shop rag
- E. 12-inch adjustable wrench
- F. Two T-slot bolts
- G. Parallel bars
- H. 6-inch steel rule
- I. Mill file
- J. Clean-up brush
- K. Workpiece (round)
- L. End-mill cutter
- M. Strip of paper

II. Procedure

CAUTION: Always wear safety glasses.

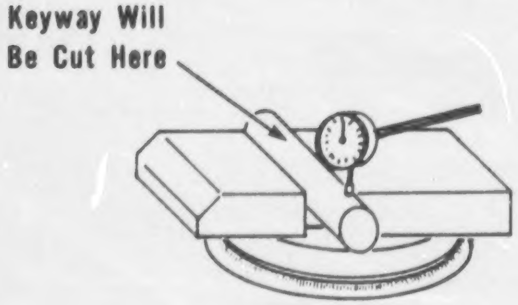
A. Make sure the power is turned off.

B. Place the vise on the mill table with the handle outward.

(NOTE: See JOB SHEET 1 for aligning procedures.)

C. Align the workpiece in the vise.

1. Select parallel bars that will provide the correct height for the workpiece.
2. Place the workpiece on the parallels in the vise so that the area for the keyway is in the vise jaws.
3. Tighten the workpiece in place.
4. Indicate the top surface of the workpiece with the dial indicator.



5. Align the workpiece until the needle on the indicator stays on the same mark as the workpiece is moved back and forth.

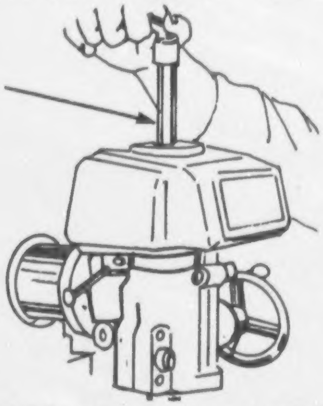
D. Install the end-mill cutter.

1. Select the correct size end-mill for the keyway to be cut.

   (NOTE: If an end-mill the size of the keyway is not available, use a smaller end-mill and make two passes.)

2. Place the end-mill in the correct size collet and place it in the collet holder.

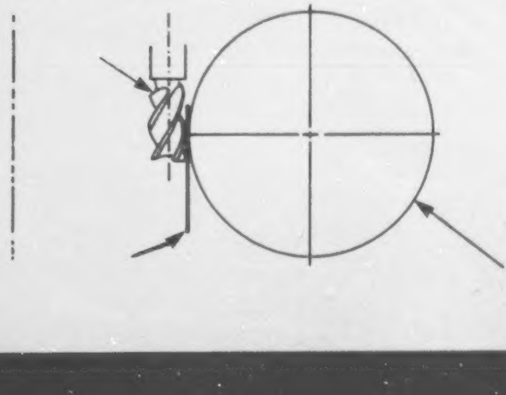
3. Tighten the collet and cutter in place by tightening the draw bar.

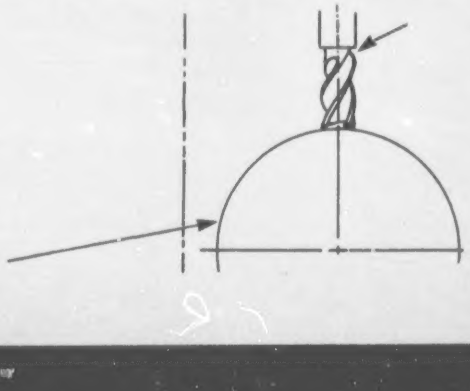


E. Center the end-mill over the workpiece.

1. Move the end of the workpiece extending from the vise up along side the end-mill.

2. Move the workpiece slowly over to the end-mill cutter.





3. As the cutter moves closer to the side of the workpiece, place a strip of paper between the end-mill cutter and the workpiece.

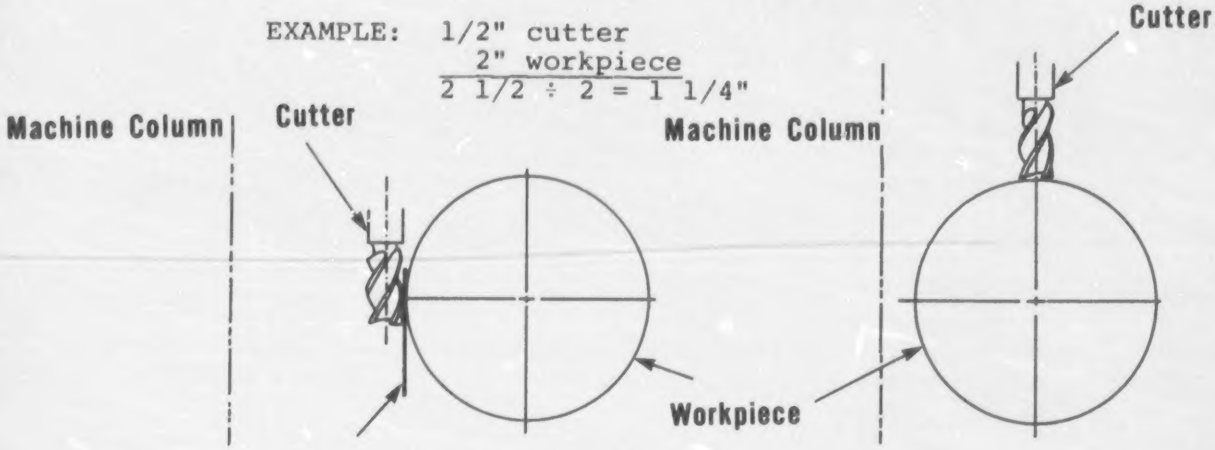
4. Move the paper up and down until the end-mill lightly touches the paper and immediately stop movement of the table.

5. Lower the table.

6. Zero the cross-feed dial.

7. Add the diameter of the cutter to the diameter of the workpiece and divide by two(2).

EXAMPLE: 1/2" cutter
2" workpiece
2 1/2 ÷ 2 = 1 1/4"



F. Set the RPM

(NOTE: The RPM will depend on the size and type of the cutter and the metal being machined.)

G. Prepare the mill for cutting.

1. Lubricate all oilers.
2. Remove all tools.
3. Make sure all covers and guards are in place.
4. Make sure feed levers are disengaged.
5. Make sure the cutter is rotating in the correct direction.
6. Lock down all clamps for table travel that should not move.

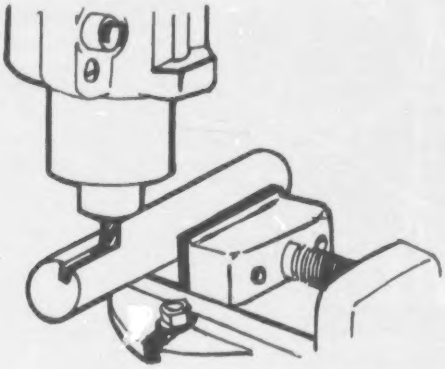
H. Set the feed on the mill

(NOTE: Check the feed chart for the correct speed for the material being machined and the cutter being used.)

I. Place a mark on the workpiece to show the stopping point.

J. Start the machine and begin cutting the keyway.

CAUTION: Make sure the cutter, vise, or other parts do not run into each other during cutting.



K. If the machine is equipped with coolant, direct a flow of coolant on the operation.

L. When the operation is complete, stop the feed and the spindle.

M. Remove burrs from the workpiece with a file.

N. Clean the machine first with the brush and then with a shop rag.

O. Return tools to their proper storage.

P. Turn in your work to your instructor.

UNIT III

MILLING OPERATIONS

JOB SHEET 3--MILL A WOODRUFF KEYSEAT ON A VERTICAL MILL

I. Tools and equipment

- A. Swivel mill vise
- B. Dial indicator
- C. T-slot cleaner
- D. Shop rag
- E. 12-inch adjustable wrench
- F. Two T-slot bolts
- G. Parallel bars
- H. 6-inch steel rule
- I. Mill file
- J. Clean-up brush
- K. Workpiece (round)
- L. Woodruff keyseat cutter
- M. Strip of paper

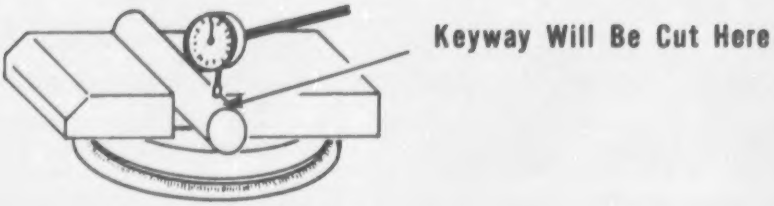
II. Procedures

CAUTION: Always wear safety glasses.

- A. Make sure the power is turned off.
- B. Place the vise on the mill table with the handle outward.

  (NOTE: See Job Sheet 1 for aligning procedures.)
- C. Align the workpiece in the vise.
  1. Select parallel bars that will provide the correct height for the workpiece.
  2. Place the workpiece on the parallels in the vise so that the area for the keyway is extending from the vise jaws.
  3. Tighten the workpiece in place.

4. Indicate the top surface of the workpiece with the dial indicator.



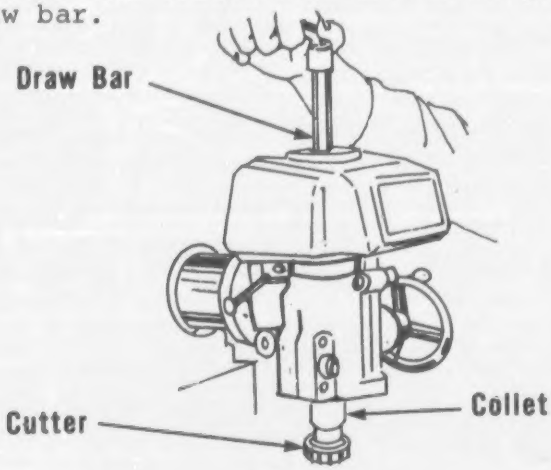
5. Align the workpiece until the needle on the indicator stays on the same mark as the workpiece is moved back and forth.

D. Install the woodruff keyseat cutter

1. Select the correct size keyseat cutter for the key to be used.

2. Place the keyseat cutter in the correct size collet and place it in the collet holder.

3. Tighten the collet and cutter in place by tightening the draw bar.



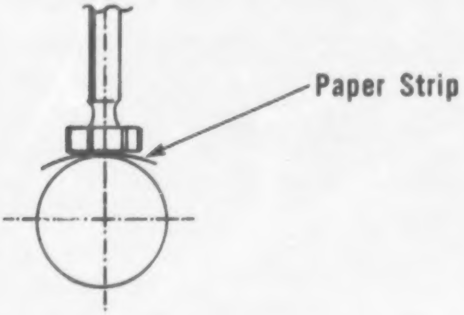
E. With the 6-inch rule, mark off the location for the keyseat on the workpiece.

F. Center the keyseat cutter over the workpiece.

1. Move the end of the workpiece extending from the vise up to the cutter.

2. Move the workpiece slowly up to the side of the cutter.

3. As the workpiece nears the cutter, place a strip of paper between the side of the cutter and the workpiece.



4. Move the paper back and forth until the keyseat cutter lightly touches the paper, and immediately stop upward movement of the table.

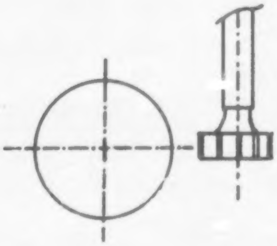
5. Move the workpiece to the backside of the cutter.

6. Zero the dial on the vertical handfeed crank.

7. Add the thickness of the cutter to the diameter of the workpiece and divide by two(2).

EXAMPLE:	1/4" cutter thickness
	1" diameter workpiece
	1 1/4 ÷ 2 = 5/8"

8. Move the workpiece up alongside the cutter by moving the vertical feed crank the amount figured in No. 7 above.



9. Position the cutter where the keyseat is to be cut.

G. Set the RPM

(NOTE: The RPM will depend on the size and type of cutter being machined.)

H. Prepare the mill for cutting

1. Lubricate all oilers.
2. Remove all tools.
3. Make sure all covers and guards are in one place.
4. Make sure all feed levers are disengaged.
5. Make sure the cutter is rotating in the correct direction.
6. Lock down all clamps for table travel that should not move.

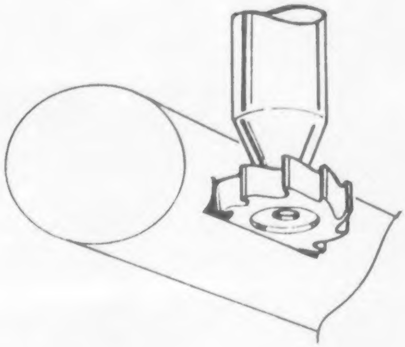
I. Turn on the mill and move the workpiece slowly toward the cutter.

J. As soon as the cutter lightly scratches the workpiece stop feeding immediately.

K. Zero the crossfeed dial.

L. Slowly feed the workpiece into the cutter to depth specified.

(NOTE: Use coolant if the machine is equipped.)



M. When the correct depth is reached, stop the feed and the spindle.

N. Back the workpiece away from the cutter and remove burrs.

O. Clean the machine first with the brush and then with a shop rag.

P. Return tools to their proper storage.

Q. Turn in your work to your instructor.

UNIT III

MILLING OPERATIONS

JOB SHEET 4--MILL A SPUR GEAR

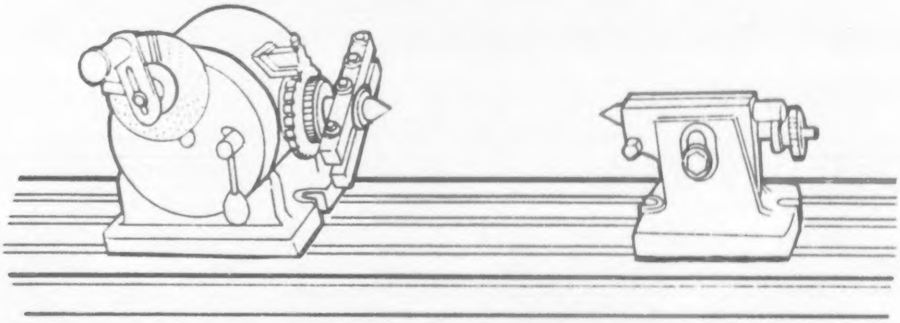
I. Tools and equipment

- A. Dividing head
- B. Footstock
- C. T-slot cleaner
- D. Shop rag
- E. Clean-up brush
- F. 12-inch adjustable wrench
- G. Four T-slot bolts
- H. Mill file
- I. Workpiece (gear blank on mandrel)
- J. Strip of paper
- K. Gear cutter
- L. Lathe dog

II. Procedures

CAUTION: Always wear safety glasses.

- A. Make sure the power is turned off.
- B. Place the dividing head on the table with the index crank facing outward.
- C. Place the footstock on the table with the center pointing toward the dividing head.

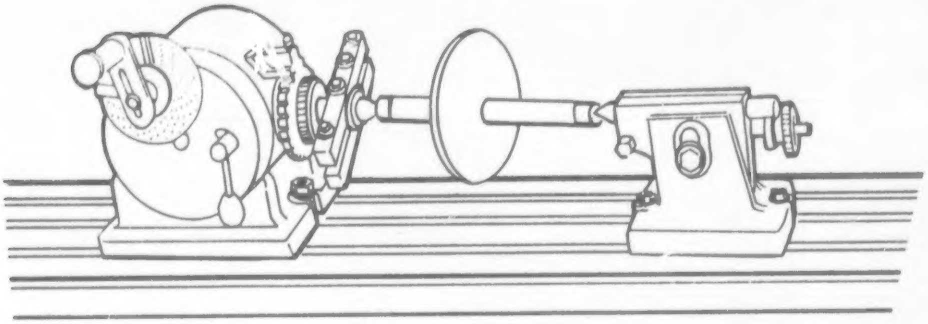


D. Set up the spur gear for gear cutting.

(NOTE: If the spur blank is not on a mandrel, it should be pressed onto a center drilled mandrel.)

1. Place a lathe dog on one end of the mandrel.
2. Place the mandrel between the dividing head centers with the lathe dog on the dividing head end.
3. Tighten the T-slot bolts on the dividing head.
4. Tighten the bolts on the footstock.

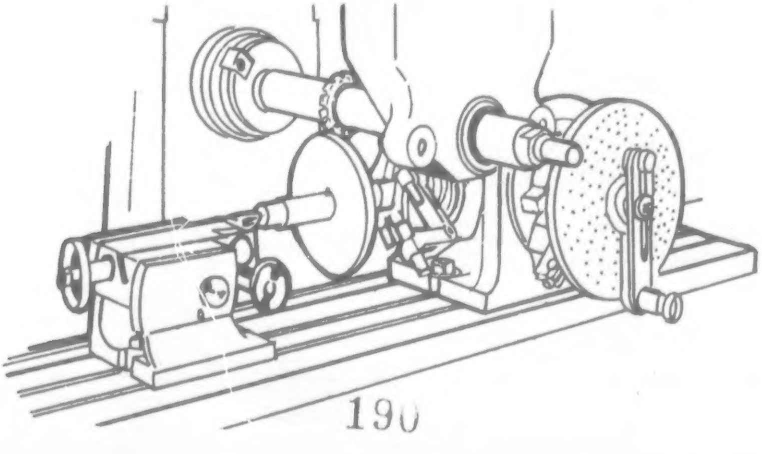
   (NOTE: Be sure there is enough adjustment on the footstock to tighten the mandrel in place.)



5. Tighten the mandrel in place and lock the footstock center stock.

E. Setup the gear cutter on the arbor.

1. Select the gear cutter for the gear specified.
2. Select an arbor for the hole size in the cutter.
3. Secure the arbor on the mill spindle and properly space the gear cutter and outboard bearing.



F. Figure the number of turns to turn the indexing crank.

(NOTE: Refer to ASSIGNMENT SHEET 2 for details.)

G. Figure the depth of cut.

(NOTE: Refer to ASSIGNMENT SHEET 2 for details.)

H. Set the correct RPM on the mill.

(NOTE: See Transparency 7 for details.)

I. Prepare the mill for cutting.

1. Lubricate all oilers.
2. Remove all tools.
3. Make sure all covers and guards are in place.
4. Make sure all feed levers are disengaged.
5. Make sure the cutter is rotating in the correct direction.
6. Lock down all clamps for table travel that will not move.

J. Set the cutter to cut the gear blank.

1. Center the cutter to cut the gear blank.
2. Start the machine.
3. Raise the workpiece until the cutter lightly scratches the spur gear blank and immediately stop.
4. Zero the dial.
5. Move the table so the cutter is in position to cut and the cutter will clear the spur gear blank.
6. Raise the table to the correct depth of cut.
7. Lock the vertical feed in place.

K. Turn on the coolant and position spray.

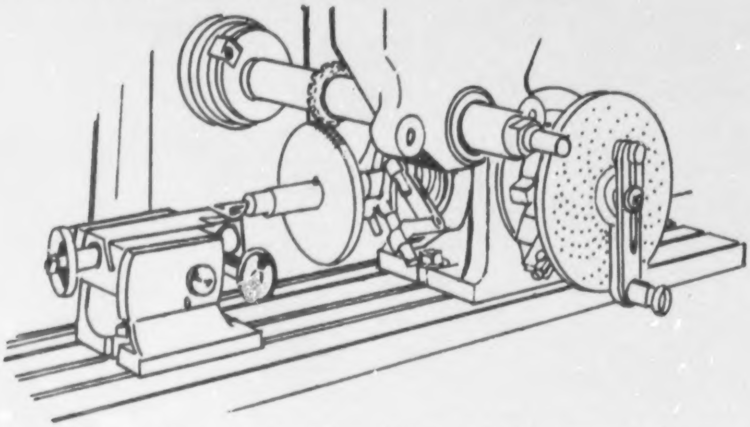
L. Set proper feed and make one pass.

(NOTE: More than one pass may be required on lighter milling machines and for larger depth cuts.)

M. When the cut is completed, stop the machine and return the cutter to the starting position.

N. Rotate the indexing crank the proper number of turns.

O. Start the machine and cut the next tooth.



P. Repeat this process until all teeth have been cut.

Q. Stop the machine and lower the table.

R. Remove burrs.

S. Clean the machine first with the brush and then with the shop rag.

T. Return tools to their proper storage.

U. Turn in your work to your instructor.

UNIT III

MILLING OPERATIONS

ANSWERS TO ASSIGNMENTS

Assignment Sheet 1

A. 115-127

B. 357-458

C. 320

D. 533-666

Assignment Sheet 2

A. 1 19/21 turns
21 hole

B. 3 1/13 turns
39 hole

C. 3 3/11 turns
33 hole

Assignment Sheet 3

A. .616

B. .360

C. .784

UNIT III

MILLING OPERATIONS

TEST PART 1

1. Explain the purpose of a milling machine.

2. Match the terms associated with milling operations to the correct definition by writing the number of each term on the right in the correct blank on the left.

____a. The centerline of the workpiece or stock.

____b. A shaft or spindle on the milling machine that holds mill cutters.

____c. The line or area that indicates a safe distance from a cutter or machine.

____d. A key or group of keys on a mechnical shaft that fit into a keyway or keyways in another part so they can slide back and forth.

____e. Upright or at a right angle to the ground.

____f. Parallel to the ground or level.

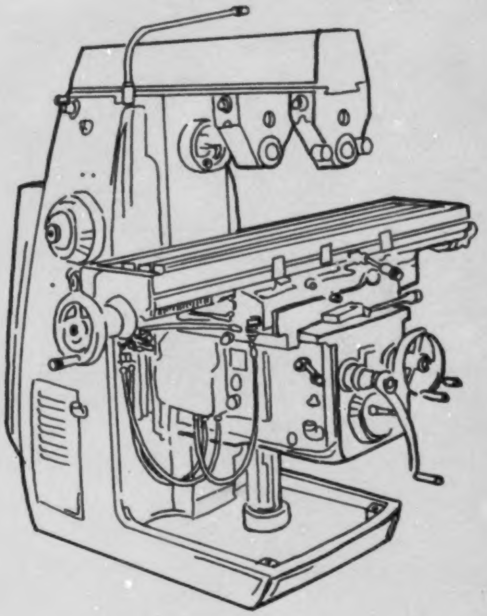
____g. The length of a curved outside edge of a round part.

____h. The process of dividing round or other shaped workpieces into equal divisions or spaces using the dividing head.

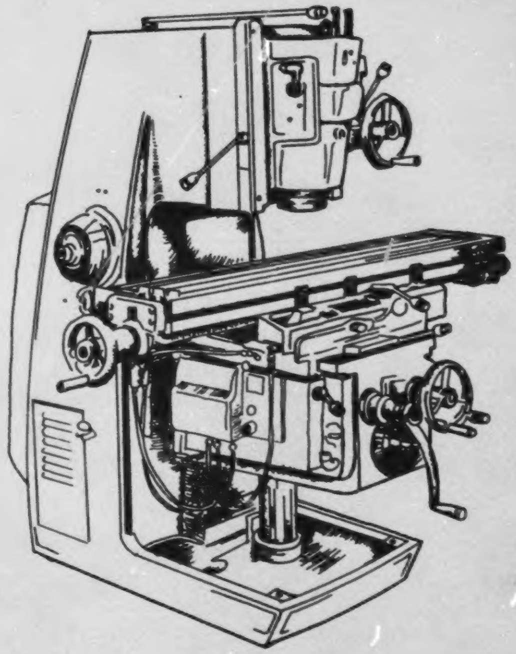
____i. When something winds around a round object as it moves along the object.

1. Arbor
2. Axis
3. Circumference
4. Horizontal
5. Indexing
6. Safety
7. Spiral
8. Splines
9. Vertical

3. Identify the types of milling machines by writing the name of each in the space provided.



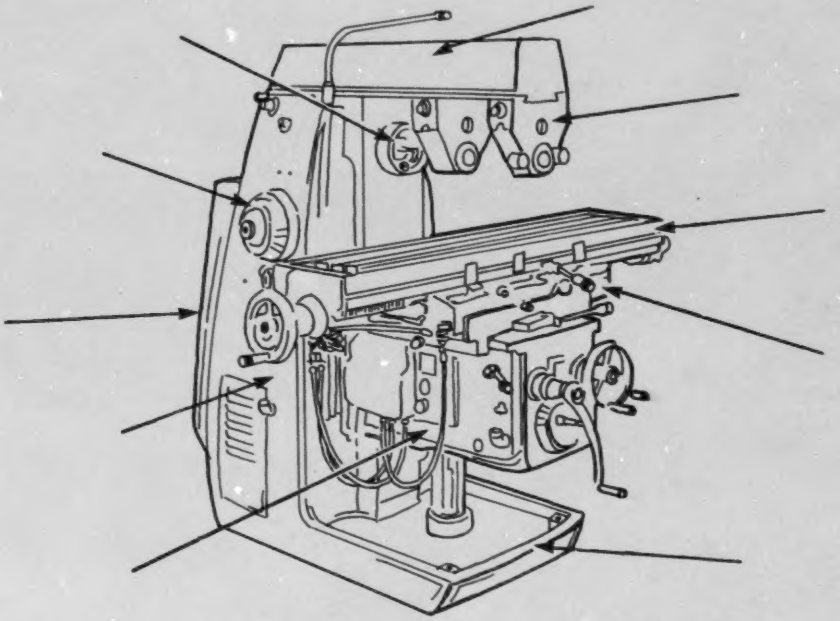
a. ______________________________



b. ______________________________

4. Identify the parts of a milling machine by labeling the illustration below with the correct name from the list.

Column
Base
Knee
Saddle
Table
Overarm
Speed selector
Spindle
Arbor
Motor assembly



5. Point out the correct safety practices to follow when operating the milling machine by answering TRUE or FALSE to each of the following statements.

______a. Safety glasses should be worn only when the machine is running.

______b. Clean the table before mounting accessories.

______c. Cutters can rotate either direction and still cut.

______d. Cutters should be handled with shop rags.

______e. The arbor nut should be tightened by using the power for the spindle.

______f. Make all adjustments with the machine stopped.

______g. It is better to use the same spindle speed and feed for machining all parts.

______h. Use a ball-pin hammer to seat the workpiece in the vise.

______i. Leave all handwheels engaged for quick adjustments during operations.

______j. Use hand feed when bringing the workpiece up to the cutter.

UNIT III

MILLING OPERATIONS

TEST PART 2

1. Identify the work holding devices used on the milling machine by writing each of the following names by the correct illustration.

Plain mill vise

T-slot bolt

T-slot clamp

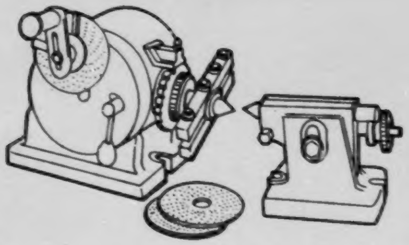
Step blocks

Strap blocks

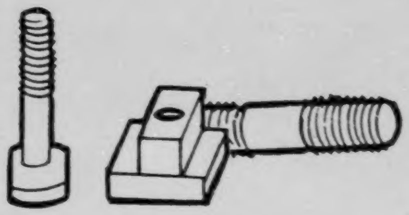
Screw jack

Dividing head

Rotary table



a. ______________________________



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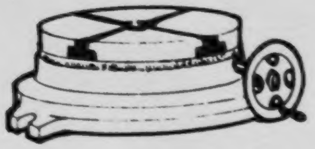
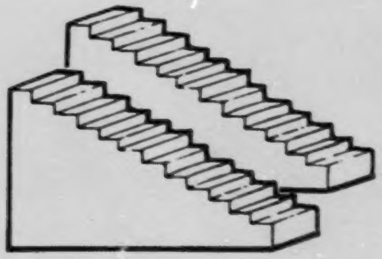
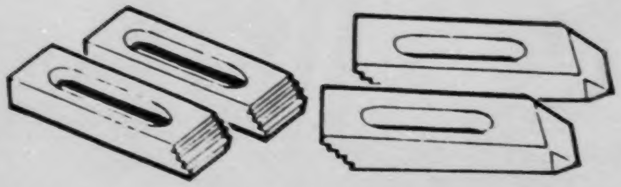


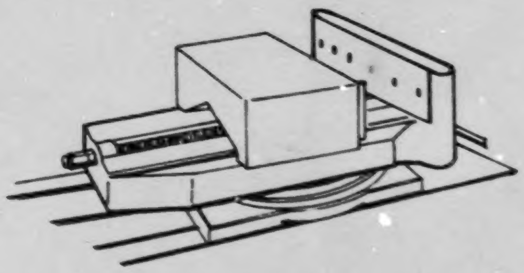
c. ______________________________



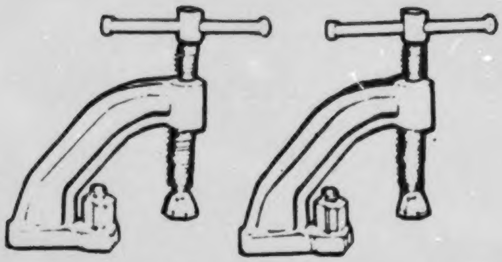
d. ______________________________



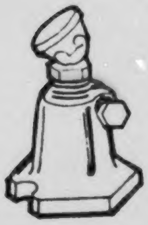
e. ______________________________



f. ______________________________



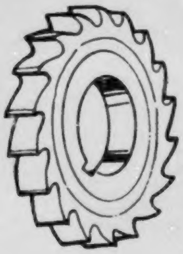
g. ____________________________



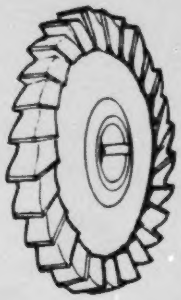
h. ____________________________

2. Identify the types of milling cutters used on the milling machine by writing each name in the list below in the correct blank.

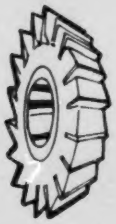
Face-mill cutter
Key-seat cutter
T-slot mill cutter
End-mill cutter
Helical plain mill cutter
Flycutter
Plain mill cutter
Side mill cutter
Metal slitting saw
Angle mill cutter
Formed tooth cutter
Boring bar



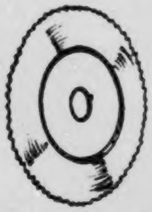
a. ____________________________



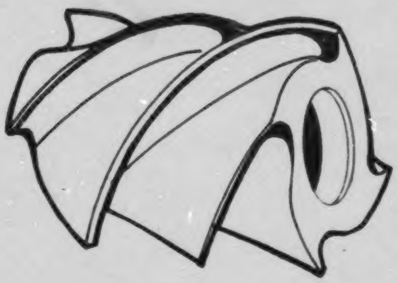
b. ____________________________



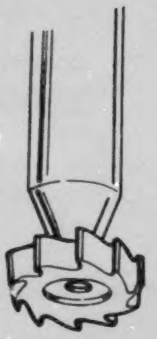
c. ____________________________



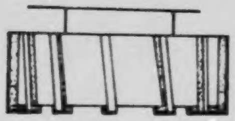
d. ____________________________



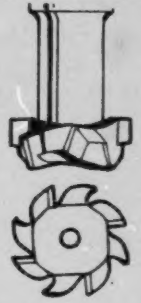
e. ______________________________



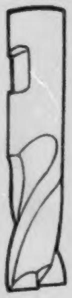
f. ______________________________



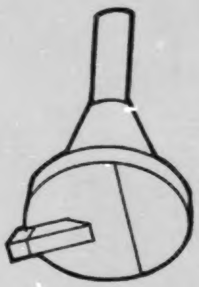
g. ______________________________



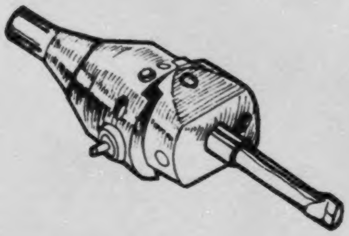
h. ______________________________



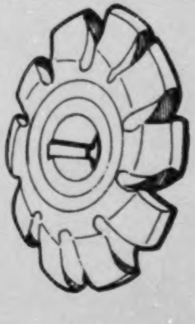
i. ______________________________



j. ______________________________



k. ______________________________



l. ______________________________

UNIT III

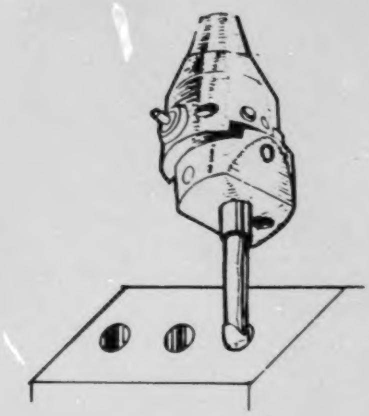
MILLING OPERATIONS

TEST PART 3

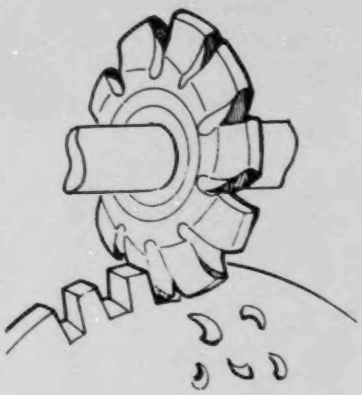
1. Identify the types of operations performed on the milling machine by writing each of the names listed below in the space by the correct illustration.

Slitting
Keyway cutting
Angle cutting
Straddle milling
Dovetail cutting
Boring

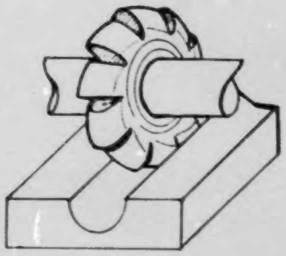
Facing
Form cutting
Gear cutting
Woodruff keyseat cutting
T-slot cutting



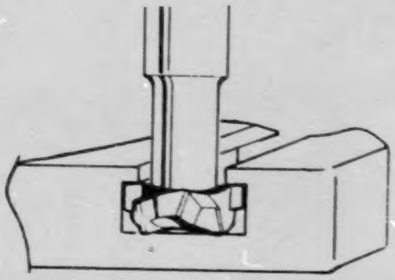
a.____________________________



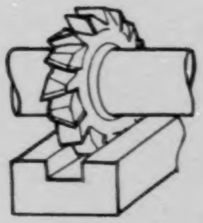
b.____________________________



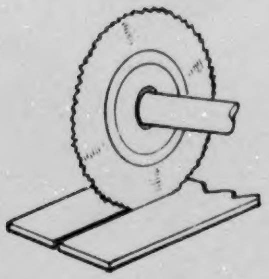
c.____________________________



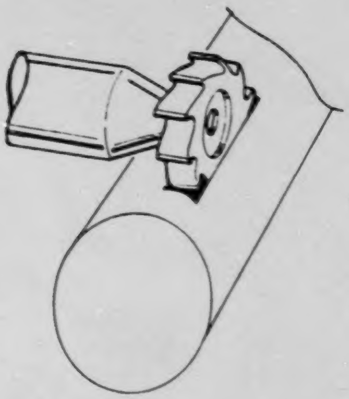
d.____________________________



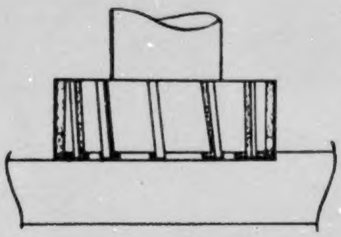
e. ____________________



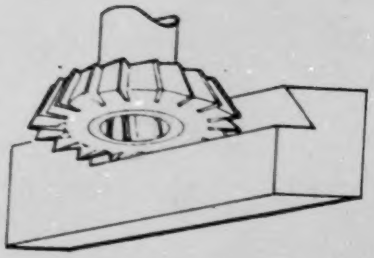
f. ____________________



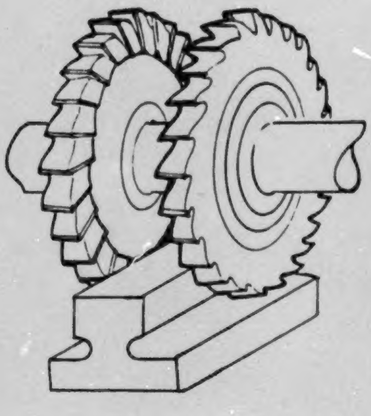
g. ____________________



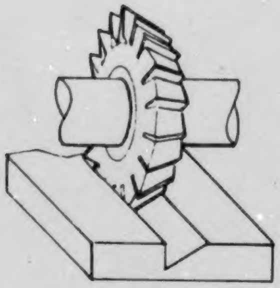
h. ____________________



i. ____________________



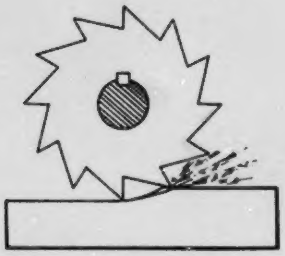
j. ____________________



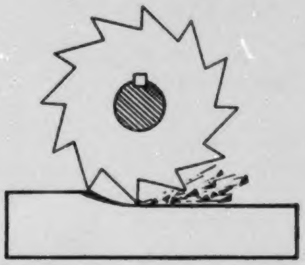
k.______________________________

2. Select the correct method of milling by drawing arrows on the workpiece and cutter illustrated below to show movement for each.

a. Conventional milling



b. Climb milling



3. Identify the things to consider when setting feeds and speeds on the milling machine by placing a "✓" in front of each listed below.

____a. Type of metal being machined.

____b. Length of workpiece.

____c. Hardness of metal.

____d. Type of cutting tool being used.

____e. Type of vise holding workpiece.

____f. Type of cutter being used.

____g. Amount of metal being removed.

____h. If a coolant is being used.

UNIT III

MILLING OPERATIONS

ANSWERS TO TEST

PART 1

1. Answer should include:

    a. The milling machine removes metal from a workpiece which is fed into a multi-toothed cutter.

    b. The milling machine is used to cut flat and uneven surfaces, drill, bore, cut gears that are spiral or cam shapes, and cut slots.

2. a. 2
    b. 1
    c. 6
    d. 8
    e. 9
    f. 4
    g. 3
    h. 5
    i. 7

3. a. Horizontal
    b. Vertical

4. a. Motor assembly
    b. Speed selector
    c. Overarm
    d. Arbor
    e. Spindle
    f. Table
    g. Saddle
    h. Knee
    i. Base
    j. Column

5. a. False
    b. True
    c. False
    d. True
    e. False
    f. True
    g. False
    h. False
    i. False
    j. True

PART 2

1. a. Dividing head
    b. T-slot bolt
    c. Rotary table
    d. Step blocks
    e. Strap blocks
    f. Vise
    g. T-slot bolt
    h. Screw jack

2. a. Plain mill cutter
    b. Side mill cutter
    c. Angle mill cutter
    d. Metal slitting saw
    e. Helical cutter
    f. Keyseat cutter
    g. Face mill cutter
    h. T-slot bolt
    i. End mill cutter
    j. Flycutter
    k. Boring bar
    l. Formed cutter

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PART 3

1. a. Boring
   b. Gear cutting
   c. Form cutting
   d. T-slot cutting
   e. Keyway cutting
   f. Slitting
   g. Woodruff keyseat cutting
   h. Facing
   i. Dovetail cutting
   j. Straddle milling
   k. Angle cutting

3. a. ✓
   b.
   c. ✓
   d. ✓
   e.
   f. ✓
   g. ✓
   h. ✓

UNIT IV

GRINDING OPERATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to explain the operation of a grinder, identify the various types of grinding machines found in a machine shop, and list some of their basic operations. The student will also be able to use the correct terminology and safety practices in performing various grinding operations. This knowledge will be evidenced through demonstration and by satisfactorily completing the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student will be able to:

1. Explain the process of removing metal with a grinder.
2. Match terms associated with grinding operations to the correct definition.
3. Identify the types of grinding machines used in the machine shop.
4. Point out the parts of the pedestal grinder.
5. Select the correct safety practices to follow when operating grinders.
6. Identify the accessories that are used in grinding operations.
7. Point out the basic grinding operations of the various grinding machines used in a machine shop.
8. Demonstrate the ability to:
    a. Mount a grinding wheel on a straight spindle grinder.
    b. Dress a grinding wheel.
    c. Sharpen a twist drill bit.
    d. Grind a general purpose tool for the lathe.
    e. Grind a finishing tool for the lathe.
    f. Grind a threading tool for the lathe.

UNIT IV

GRINDING OPERATIONS

SUGGESTED TEACHING ACTIVITIES

I. Objective sheet

  A. Discuss the unit objective with the students

  B. Discuss each specific objective with the students

  C. Have the students complete the objectives in the most logical sequence for shop organization

  D. Add any objectives necessary

II. Information sheets

  A. INFORMATION SHEET 1--INTRODUCTION TO GRINDING

    1. Explain the operation of the grinder

    2. Discuss the types of grinding machines (Transparency 1 & 2)

    3. Identify the parts of the pedestal grinder (Transparency 3)

    4. Discuss the safety practices associated with the operation of the grinder

  B. INFORMATION SHEET 2--GRINDING ACCESSORIES AND OPERATIONS

    1. Explain the use of each of the grinding accessories

    2. Discuss the various types of grinding wheels and the marking system (Transparency 4)

    3. Discuss the various operations performed on each type of grinder

    4. Explain the use of the tool makes grinder (Transparency 5)

III. Transparency masters

  (NOTE: Transparencies are included in the student manuals as information sheets.)

  A. TM-1--TYPES OF UTILITY GRINDERS

  B. TM-2--SPECIALIZED GRINDERS

  C. TM-3--PARTS OF THE PEDESTAL GRINDER

- D. TM-4--THE GRINDING WHEEL MARKING SYSTEM
- E. TM-5--PARTS OF THE TOOLMAKER'S GRINDER
- F. TM-6--PARTS OF THE LATHE TOOL
- G. TM-7--CUTTING TOOL ANGLES

IV. Job sheets

- A. JOB SHEET 1--MOUNT A GRINDING WHEEL ON A STRAIGHT SPINDLE GRINDER
  1. Explain the importance of a good grinding wheel
  2. Demonstrate the checking procedure for the grinding wheel
- B. JOB SHEET 2--DRESS A GRINDING WHEEL
  1. Discuss the results of using uneven or glazed wheels for grinding
  2. Demonstrate the procedure for dressing a grinding wheel
  3. Reinforce the safety fasteners associated with the operation
- C. JOB SHEET 3--SHARPEN A TWIST DRILL
  1. Provide a dull, used drill bit for each student.
  2. Reinforce safety practices
  3. Discuss proper clearance and cutting lip angles
  4. Demonstrate the procedures for sharpening the drill bit
- D. JOB SHEET 4--GRIND A GENERAL PURPOSE TOOL FOR THE LATHE
  1. Discuss the parts of the lathe tool

     (Transparency 6)
  2. Explain the importance of proper cutting tool angles (Transparency 7)
  3. Demonstrate the procedures for grinding a lathe tool
- E. JOB SHEET 5--GRIND A FINISHING TOOL FOR THE LATHE
  1. Explain the angles for the finishing tool
  2. Demonstrate the procedures for grinding the tool

F. JOB SHEET 6--GRIND A THREADING TOOL FOR THE LATHE

1. Explain the angles and use of the center gauge
2. Demonstrate the procedures for grinding a threading tool

V. Unit test

A. The unit test is divided into two parts

(NOTE: Each part covers one information sheet.)

B. Various approaches may be used in testing:

1. Each part of the test may be given as the student reviews the information on each information sheet
2. Give the entire test upon completion of all the information sheets in the unit
3. Give one or more parts of the test as an additional assignment, or to reinforce areas the student did not understand

C. Add test parts corresponding to any information area or sheets added to the unit

VI. Answers to unit test

A. Answers are based on total information presented in the unit

B. For convenience of grading, add corresponding answer sheets for additional test parts

VII. References

A. Walker, John R. Modern Metalworking. Goodheart-Wilcox Co., Inc. South Holland, Illinois 1976

B. A Suggested Basic Course Outline for General Metal Trades Cluster. Occupational Curriculum Laboratory, East Texas State University, Commerce, Texas 75428

C. Teirer and Tatro. Machine Tool Metalworking. McGraw-Hill, New York

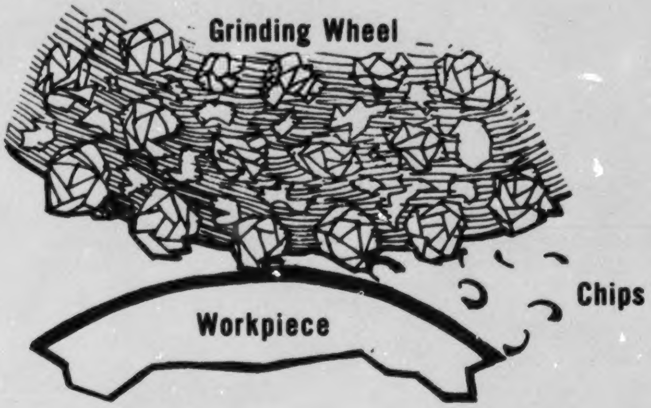
UNIT IV

GRINDING OPERATIONS

INFORMATION SHEET 1--INTRODUCTION TO GRINDING

I. Operation of the grinder

A. The grinder removes metal from the workpiece in small chips which are cut by the abrasive wheel with thousands of small cutting edges.



B. Grinding can be done by hand or in combination with other machine tools, on flat, round, or uneven surfaces.

II. Terms and definitions

A. Abrasive--a rough material used to remove or cut metal from a workpiece by a rubbing or friction process.

B. Dressing the wheel--a process of smoothing or aligning the grinding wheel.

C. Loaded--The condition of a grinding wheel when the pores or surface of the wheel is full of metal particles and will not grind properly.

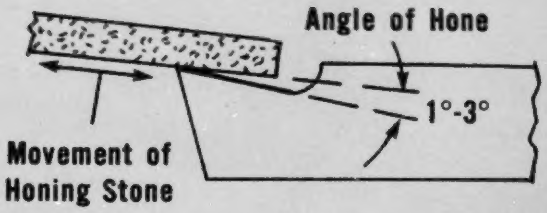
D. Glazed--The condition of a grinding wheel when the surface of the wheel becomes slick and will not grind.

E. Carbide-tipped--The term applied to a cutter which has a cutting edge made of hard carbide.

F. Clearance Relief Angle--The area on a cutting tool that is shaped so it will not rub on the workpiece being cut.

G. Rake--The area on a cutting tool that is shaped to provide a cutting edge.

H. Hone--The process of removing roughness or small metal chips from the cutting edges of a cutting tool.



III. Types of grinding machines

A. Utility--General purpose grinder used in hand held operations.

1. Bench grinder

2. Pedestal grinder

3. Carbide bench grinder

B. Portable--A hand-held grinder used in construction finishing to smooth welds, rust, and uneven areas.

C. Toolmaker's--A grinding machine used to make, resharpen, or repair cutting tools such as end-mill or taps.

D. Surface--A grinding machine used to produce very accurate finishes on flat surfaces.

E. Cylindrical--A grinding machine which holds the workpiece between centers.

(NOTE: A similar operation is done on the lathe when grinding a workpiece between centers with the toolpost grinder.)

F. Centerless--A grinding machine which holds the workpiece on a workrest rather than between centers.

IV. Parts of the pedestal grinder

A. Pedestal--Provides support for the motor and water pot.

B. Water pot--Allows the workpiece being ground to be cooled so that it will not become too hot to hold.

C. Tool rest--Provides a flat surface to guide the workpiece or to be used as a handrest.

D. Wheel--Serves as an abrasive disc which is the cutting tool of the grinder.

E. Motor--Provides the power source for turning the spindle.

F. Shield--Keeps sparks and chips from flying into the operator's eyes and face.

G. Wheel guard--Prevents sparks and metal particles from being thrown from the grinding wheel.

H. Switch--Provides a convenient control to start or stop the motor.

V. Grinding safety practices

A. Adjust the tool rest so that it is no more than 1/8 inch from the wheel.

B. Grind on the face of the wheel only, never on the side.

C. Keep the wheel dressed properly.

(NOTE: Tools cannot be ground accurately if the surface of the wheel is not flat.)

D. Grind across the entire face of the wheel to keep from grooving the wheel.

E. Stand to one side of the wheel when you turn it on.

F. Allow the motor to reach full speed before beginning grinding.

G. Keep the tool moving from side-to-side to prevent overheating.

H. Cool the tool often in the cooling pot.

I. Be sure all guards are on the grinder before operating it.

J. Do not use a wheel that vibrates or that you think is cracked.

K. Keep your fingers away from the grinding wheel.

L. Always wear protective safety glasses or shield and also use the shields on the grinder.

M. Do not grind soft metals such as aluminum or brass because these will clog the wheel.

N. Make all adjustments with the machine completely stopped.

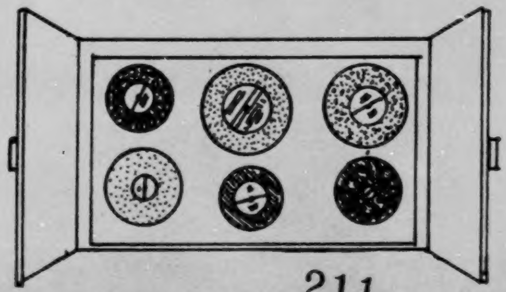
O. Use the wheel dresser only after receiving instructions in how to use it.

P. Allow the machine to completely stop before leaving it.

Q. Check all grinding wheels for soundness before installing.

R. Do not operate a grinding wheel at a higher speed than recommended on the label.

S. Store grinding wheels separately and in a protected place.



UNIT IV

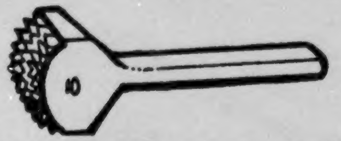
GRINDING OPERATIONS

INFORMATION SHEET 2--GRINDING ACCESSORIES AND OPERATIONS

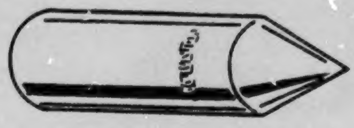
I. Accessories

A. Dressers

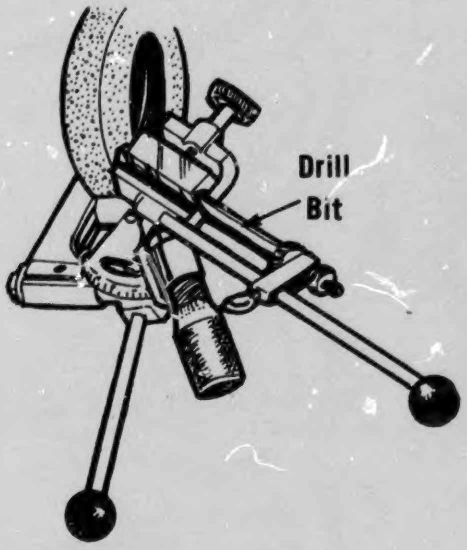
1. Mechanical handdresser--Used to even the grinding stones on utility grinders.



2. Diamond dresser--Used to dress the grinding stones on surface and toolmaker's grinders

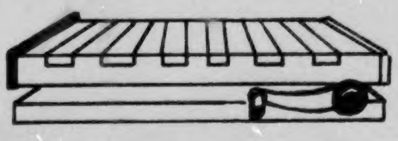


B. Drill grinding attachment--Attaches to the grinder housing to provide a guide for accurately sharpening drill bits.



C. Magnetic chuck

1. Used for holding workpieces on the surface grinder table.



2. Holds the workpiece to the chuck by magnetism.

D. Grinding wheels

1. Types of abrasives

   a. Aluminum oxide--Used for grinding high tensile strength materials such as steel.

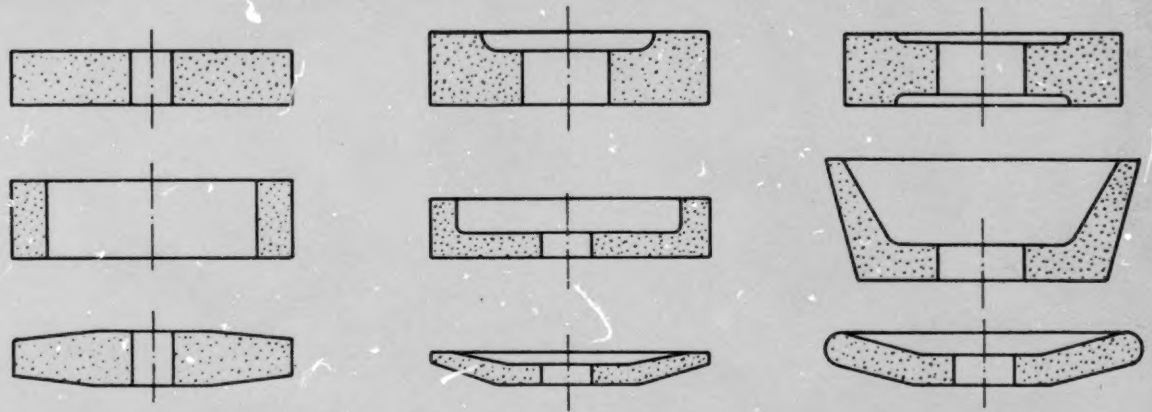
   b. Silicon carbide--Used for grinding low tensile strength materials.

   EXAMPLES: Aluminum, copper, cast iron

2. Grain sizes--Sized from 10 to 600.

   (NOTE: The smaller number indicates the courser wheel, and the larger number indicates the finer wheel.)

3. Shaper--Grinding wheels are shaped according to the different job requirements.

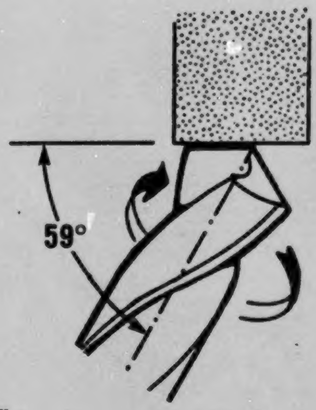


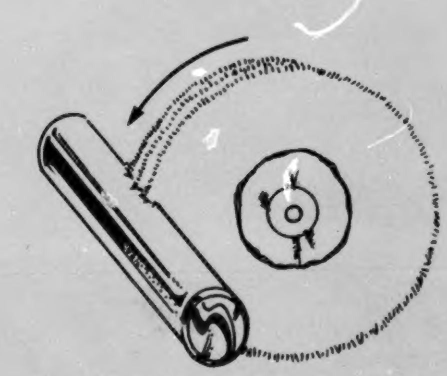
II. Basic grinding machine operations

A. Utility grinders

1. Off-hand grinding

   EXAMPLE: Drill grinding

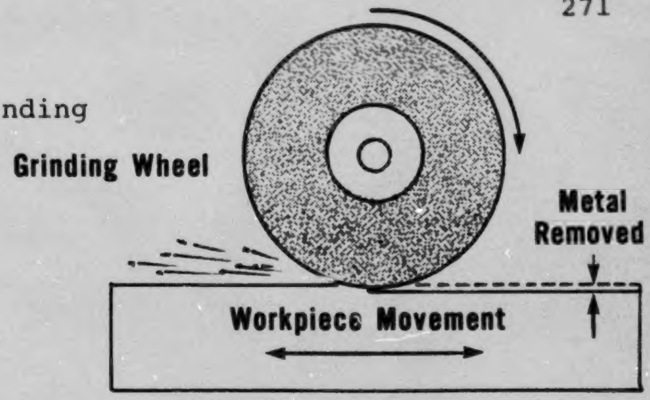




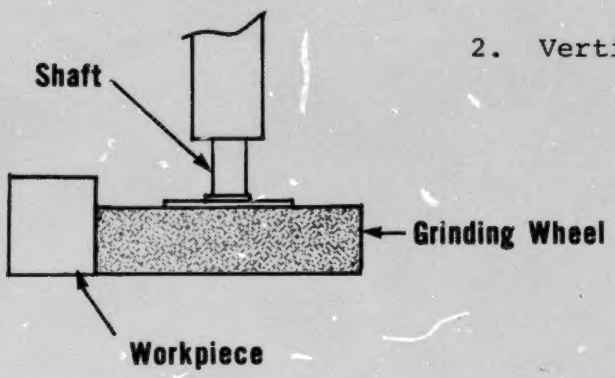
2. Buffing

B. Surface grinder

1. Horizontal shaft grinding

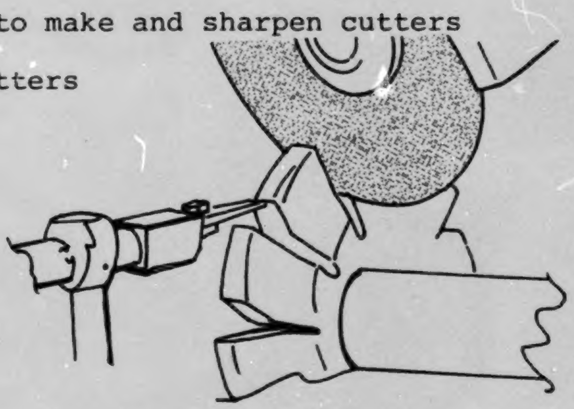

Grinding Wheel
Metal Removed
Workpiece Movement

2. Vertical shaft grinding

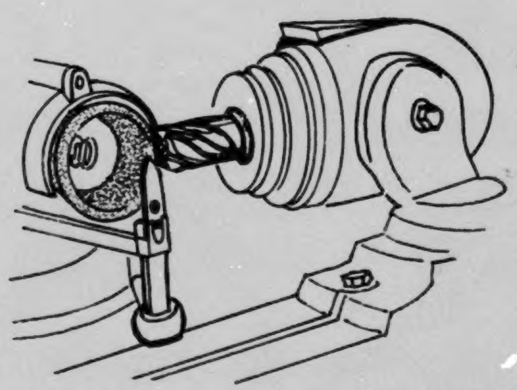

Shaft
Grinding Wheel
Workpiece

C. Tool makers grinder--Used to make and sharpen cutters

1. Grinding plain mill cutters

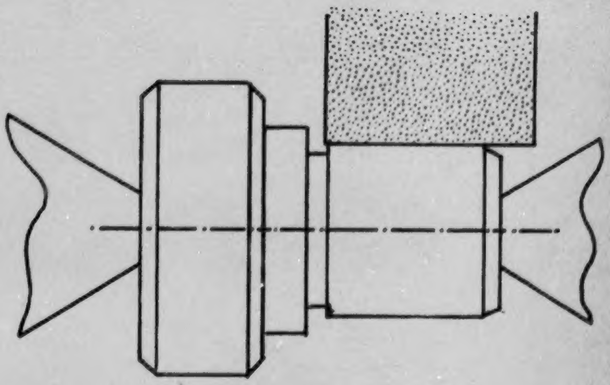


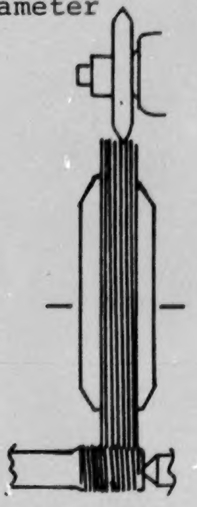
2. Grinding end-mill cutters



D. Cylindrical grinder--Produces straight or tapered surfaces on round workpieces which may be mounted between centers or in a chuck.

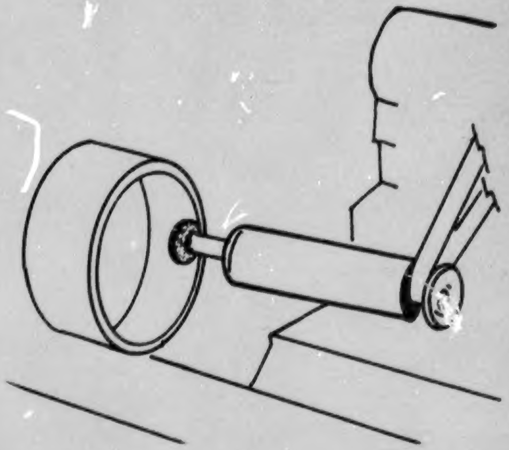
1. Plunge grinding--The face of the grinding wheel is fed into the revolving workpiece until it is ground to the desired diameter





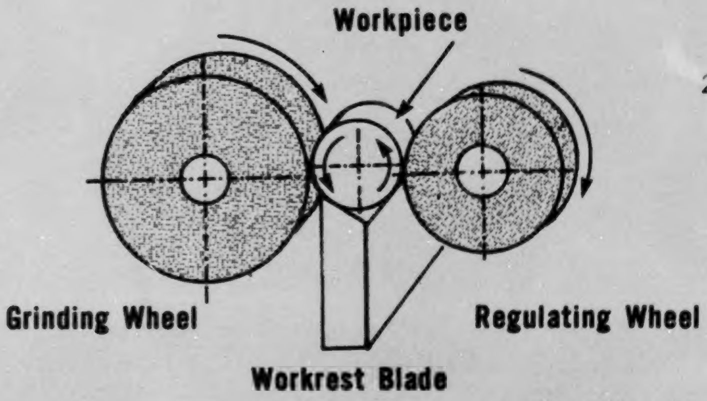
2. Form grinding--The grinding wheel is formed to produce a particular shape.

3. Internal grinding--The grinding wheel spins inside the workpiece which may or may not be turning.



E. Centerless grinder

1. Workpiece is held in position by a workrest blade and not a chuck or centers.


Workpiece
Grinding Wheel
Regulating Wheel
Workrest Blade

2. Straight or tapered parts may be produced.

UNIT IV

GRINDING OPERATIONS

JOB SHEET 1--MOUNT A GRINDING WHEEL ON A STRAIGHT SPINDLE GRINDER

I. Tools and materials

- A. New grinding wheel
- B. Two plastic handle screwdrivers
- C. 12-inch adjustable wrench
- D. Shop rag
- E. Safety glasses

II. Procedures

A. Select the grinding wheel that is correct for the grinding operation.

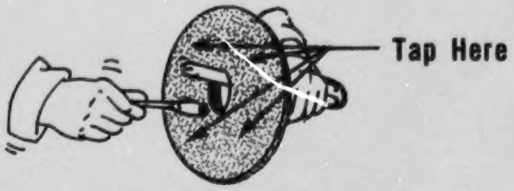
B. Look at the wheel to see if there are any cracks, chips, or dents.

C. Compare the RPM rating on the wheel to the RPM of the grinder.

(NOTE: The RPM of the wheel should always be rated higher than the grinder.)

D. Ring-test the wheel for cracks.

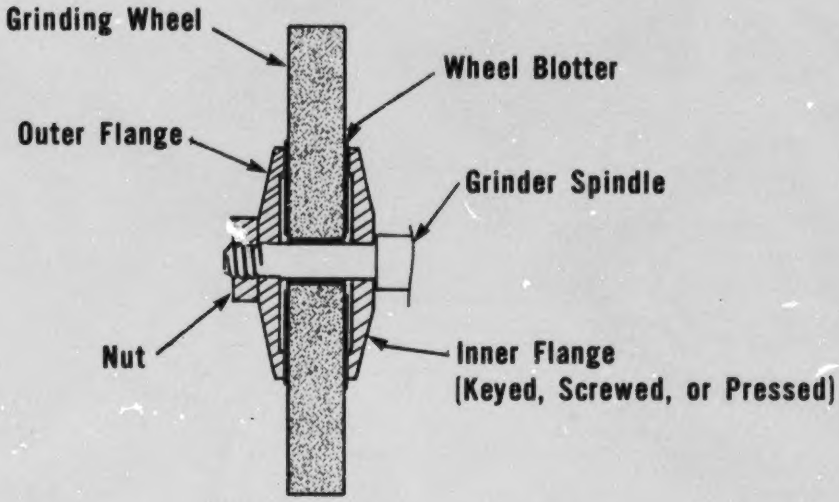
1. Place the wheel on the blade of one screwdriver.
2. Lightly tap the side of the grinding wheel with the handle of the screwdriver.



(NOTE: If the tapping of the wheel produces a ringing sound, the wheel is good. If a hollow sound is produced, the wheel may be cracked.)

E. Place the grinding wheel on the grinder spindle.

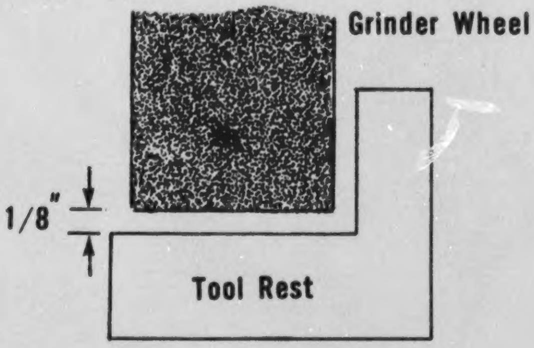
(NOTE: Make sure the blotters, inner flange, and outer flange are properly aligned, and the inner bushing does not extend beyond the side of the wheel.)


Grinding Wheel
Wheel Blotter
Outer Flange
Grinder Spindle
Nut
Inner Flange
(Keyed, Screwed, or Pressed)

F. Tighten the spindle nut snugly against the flange.

CAUTION: Do not use excessive pressure which could crack the wheel.

G. Adjust the tool rest so the clearance of the wheel is about 1/8 inch from the tool rest.


Grinder Wheel
1/8"
Tool Rest

H. Replace any covers or shields removed.

I. Turn the wheel by hand at least one turn to check for clearance.

J. Stand to one side of the grinder and turn the power on.

K. Allow it to run about one minute.

CAUTION: Stay clear of the front of the wheel, in case it does shatter.

L. Shut off power and return tools to their proper storage.

UNIT IV

GRINDING OPERATIONS

JOB SHEET 2--DRESS A GRINDING WHEEL

I. Tools and materials

   A. Glazed or uneven grinding wheel

   B. Wheel dresser

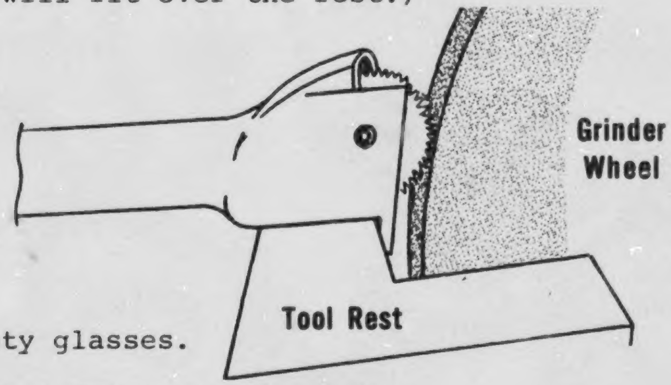
   C. 8-inch adjustable wrench

   D. Safety glasses

II. Procedures

   A. Adjust the tool rest to within 1/8 inch clearance of the grinding wheel.

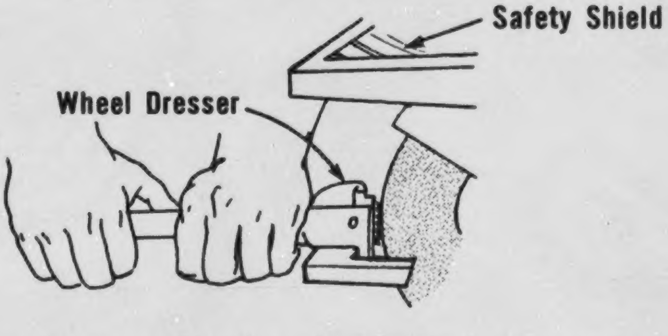
      (NOTE: If the grinder side of the tool rest is even and smooth, the rest can be adjusted so the hook of the dresser will fit over the rest.)



   B. Put on your safety glasses.

   C. Stand to one side and turn on the power.

   D. Place the dresser on (or hooked behind) the tool rest.

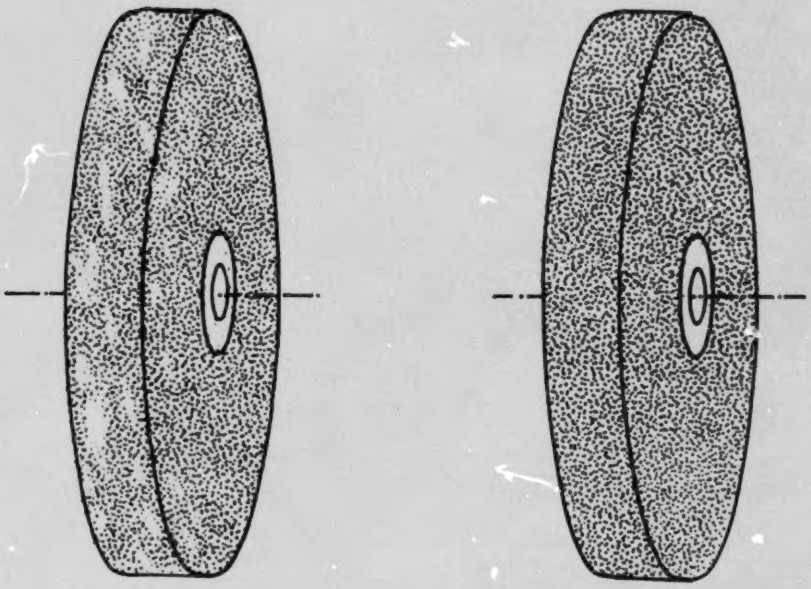


   E. Hold the dresser firmly with both hands and slowly move the dresser into the grinding wheel.

F. Move the dresser steadily back and forth across the face of the wheel.

(NOTE: Do not allow the dresser to run off the edge of the stone.)

G. Keep the dresser moving back and forth until the wheel appears to be even and clear of metal particles.



Loaded **Dressed**

H. Quickly move the dresser away from the grinding wheel.

I. Turn off the power and check the wheel.

J. If the wheel is not even and clean, repeat the process.

K. Adjust the tool rest within 1/8 inch of the wheel.

L. Turn the wheel one turn to see if it clears the tool rest.

M. Return tools to their proper storage and clean the work area.

UNIT IV

GRINDING OPERATIONS

JOB SHEET 3--SHARPEN A TWIST DRILL BIT

I. Tolls and equipment required:

A. Dull drill bit

B. Bench grinder

C. Safety glasses

D. Drill bit gauge or protractor

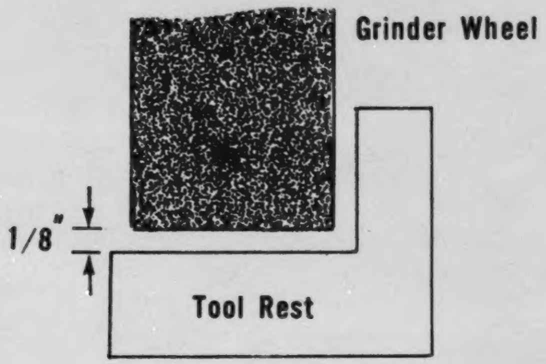
E. Oilstone

II. Procedure

A. Put on safety glasses.

B. Adjust tool rest to proper clearance.

(NOTE: Proper clearance is approximately 1/8 inch from the wheel.)



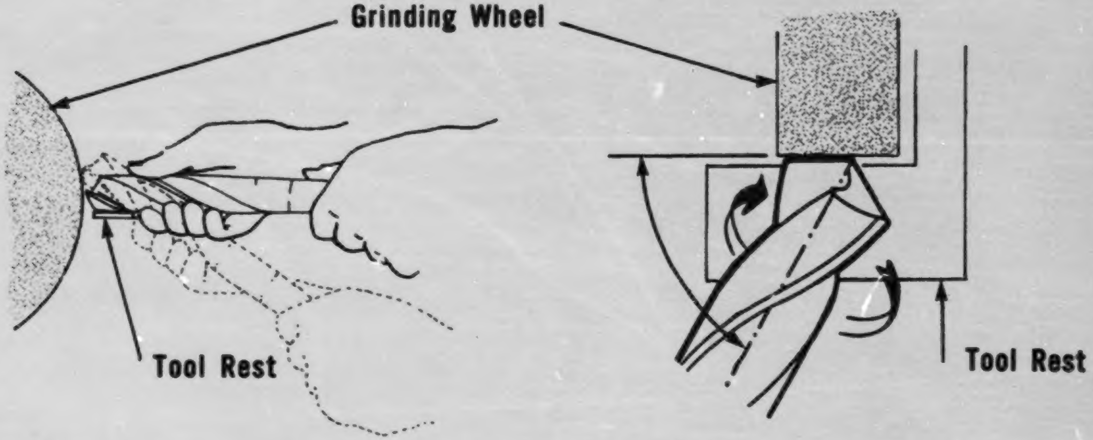
C. Turn on grinder.

D. Place drill bit on tool rest at an angle of about 59 degrees.

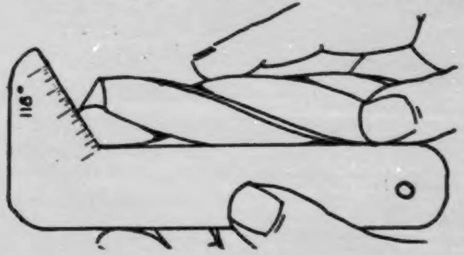
CAUTION: Do not grind on the side of the wheel.

E. Grind one lip of the drill bit by rolling the bit to the right and up.

(NOTE: This rolling of the drill bit provides back clearance.)

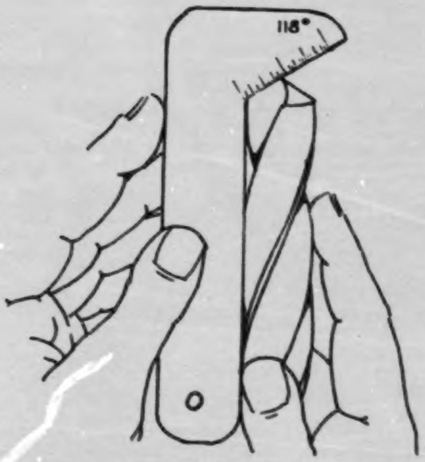

Grinding Wheel
Tool Rest
Tool Rest

F. Check the correct angle with a drill bit gauge.



G. Grind and check the other drill bit lip.

(NOTE: The point of the drill should be centered on the bit when grinding is finished.)



H. Turn off grinder.

I. Hone cutting edges of the drill bit to remove burrs.

J. Recheck all cutting angles.

K. Clean up work area.

GRINDING OPERATIONS

JOB SHEET 4--GRIND A GENERAL PURPOSE TOOL FOR THE LATHE

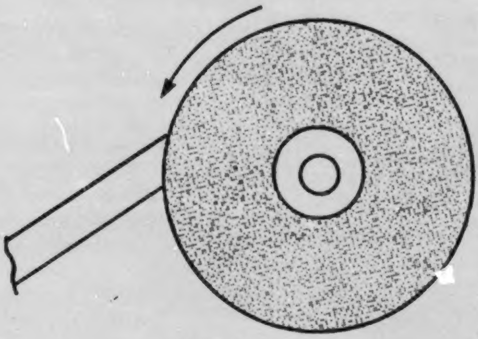
I. Tools and materials

- A. Tool steel blank
- B. Pedestal grinder
- C. Water tray
- D. Safety glasses
- E. Bevel protractor
- F. Shop rag

II. Procedures

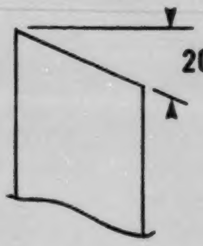
(NOTE: Procedures and illustrations are shown for a right-hand turning tool. Angles would be the same but on the opposite side of blank for a left hand tool.)

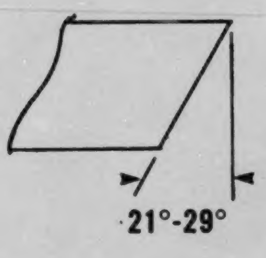
- A. Adjust the tool rest to within 1/8-inch clearance of the grinding wheel.
- B. Put on your safety glasses.
- C. Grind the end clearance angles on the tool steel blank at the correct angles.



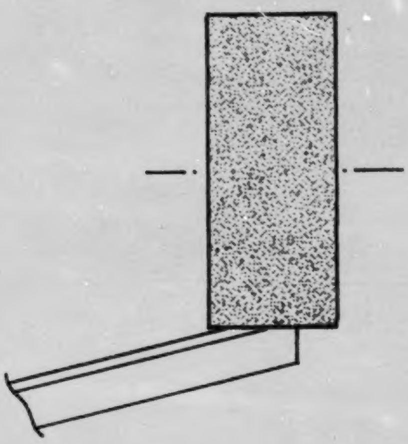
CAUTION: Cool the tool steel often.

D. Check the angles with a bevel protractor.

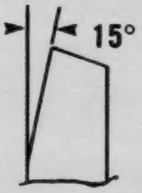


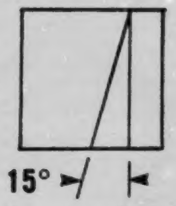


E. Grind the side cutting angle
and the side clearance angle.

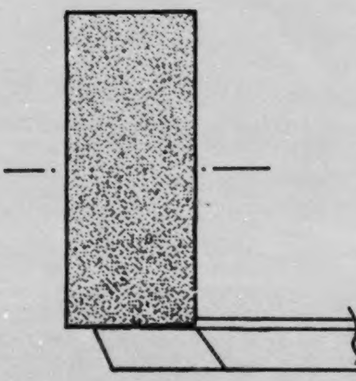


F. Check both angles with the bevel protractor.

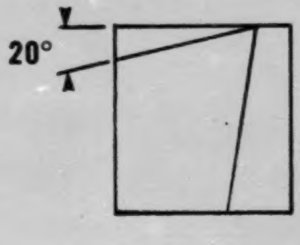




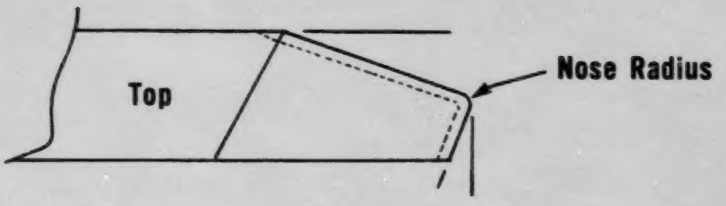
G. Grind the rake angle on the top of the tool blank.



H. Check the rake angle with the bevel protractor.



I. Grind a slight radius on the nose of the tool.



J. Recheck all angles on the tool.

K. Hone the radius and each flat ground surface on a file stone.

L. Turn off the grinder.

M. Clean up the work area.

UNIT IV

GRINDING OPERATIONS

JOB SHEET 5--GRIND A FINISHING TOOL FOR THE LATHE

I. Tools and materials

- A. Tool steel blanks
- B. Pedestal grinder
- C. Water tray
- D. Safety glasses
- E. Bevel protractor
- F. Shop rag

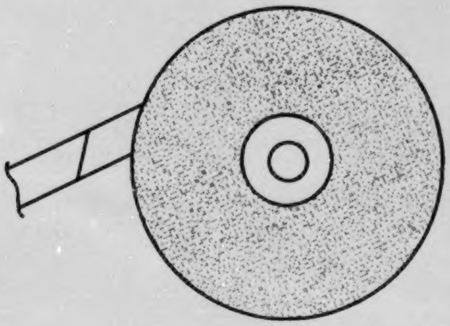
II. Procedures

(NOTE: Procedures and illustrations are shown for a right-hand finishing tool. Angles would be the same but on the opposite side of the blank for a left-hand tool.)

A. Adjust the tool rest to within 1/8-inch clearance of the grinding wheel.

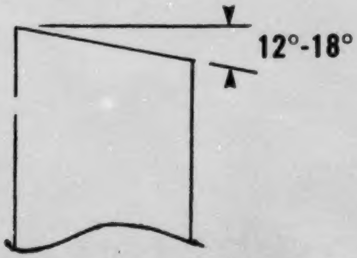
B. Put on safety glasses.

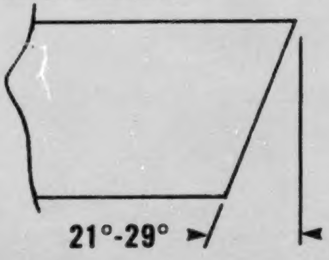
C. Grind the end clearance angles on the tool steel blank at the correct angles.



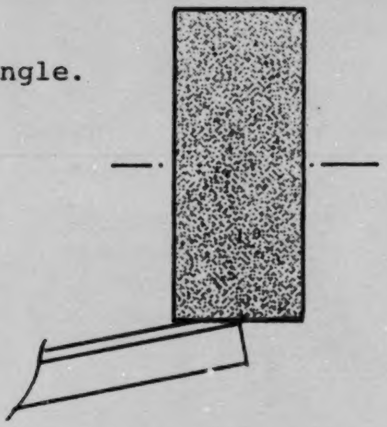
CAUTION: Cool the tool steel often.

D. Check the angles with a bevel protractor.

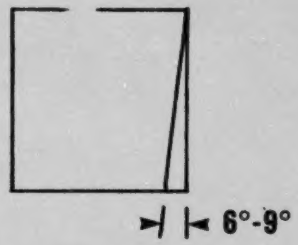




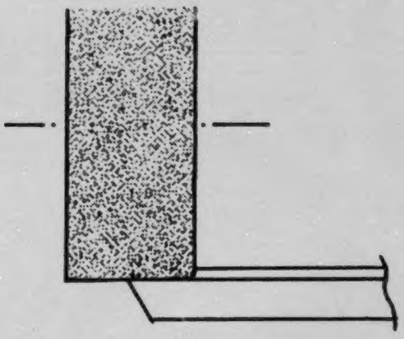
E. Grind the side clearance angle.



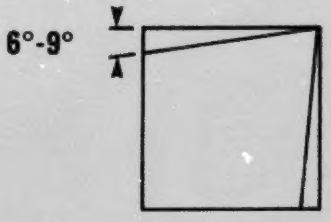
F. Check the side clearance angle with the bevel protractor.



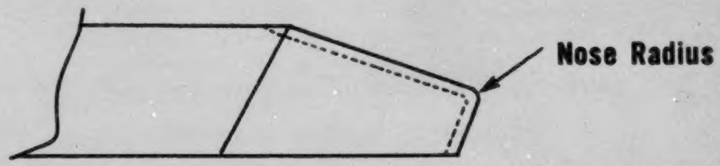
G. Grind the rake angle on the top of the tool blank.



H. Check the rake angle with the bevel protractor.



I. Grind a slight radius on the nose of the tool.



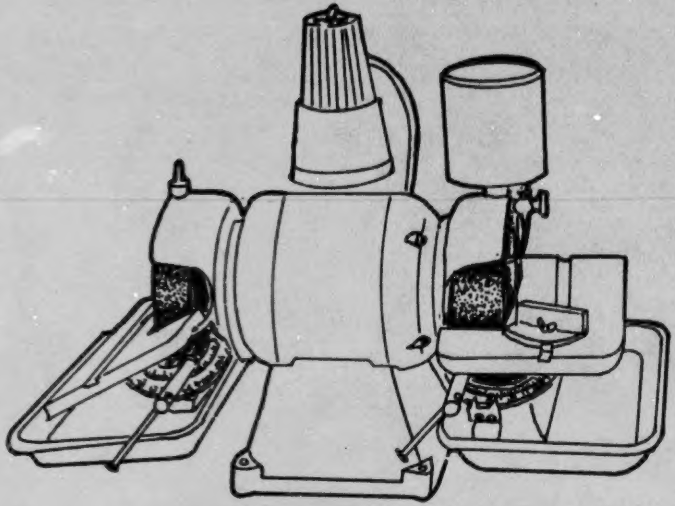
J. Recheck all angles on the tool.

K. Hone the radius and each flat ground surface on the oil stone.

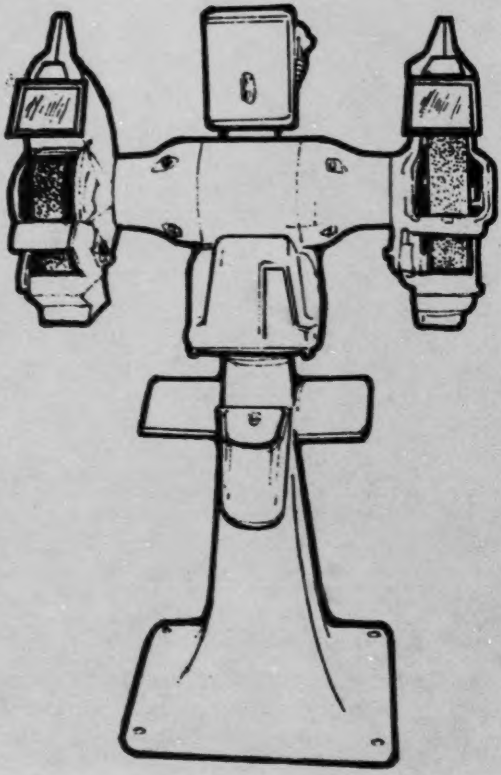
L. Turn off the grinder.

M. Clean up the work area.

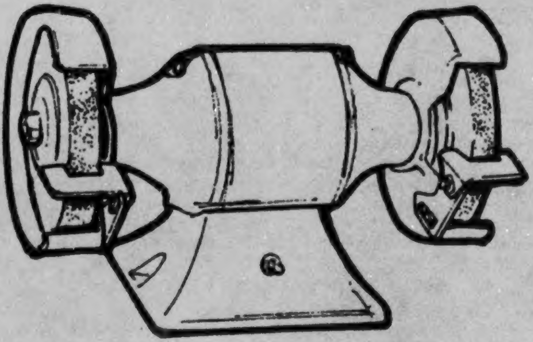
TYPES OF UTILITY GRINDERS



CARBIDE GRINDER

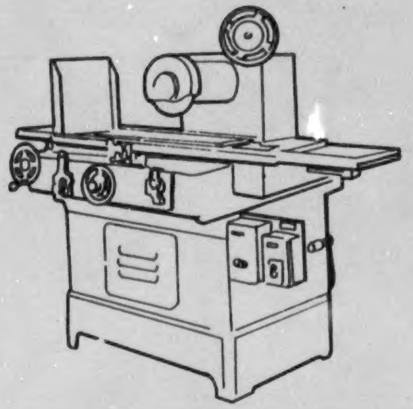


PEDESTAL GRINDER

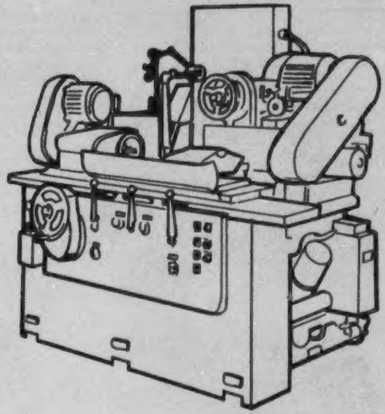


BENCH GRINDER

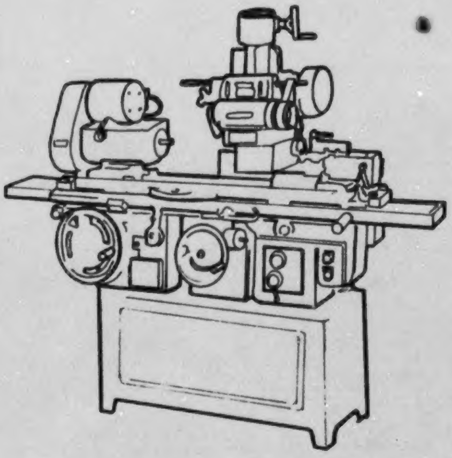
SPECIALIZED GRINDERS



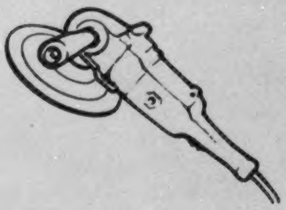
SURFACE GRINDER



CENTERLESS GRINDER

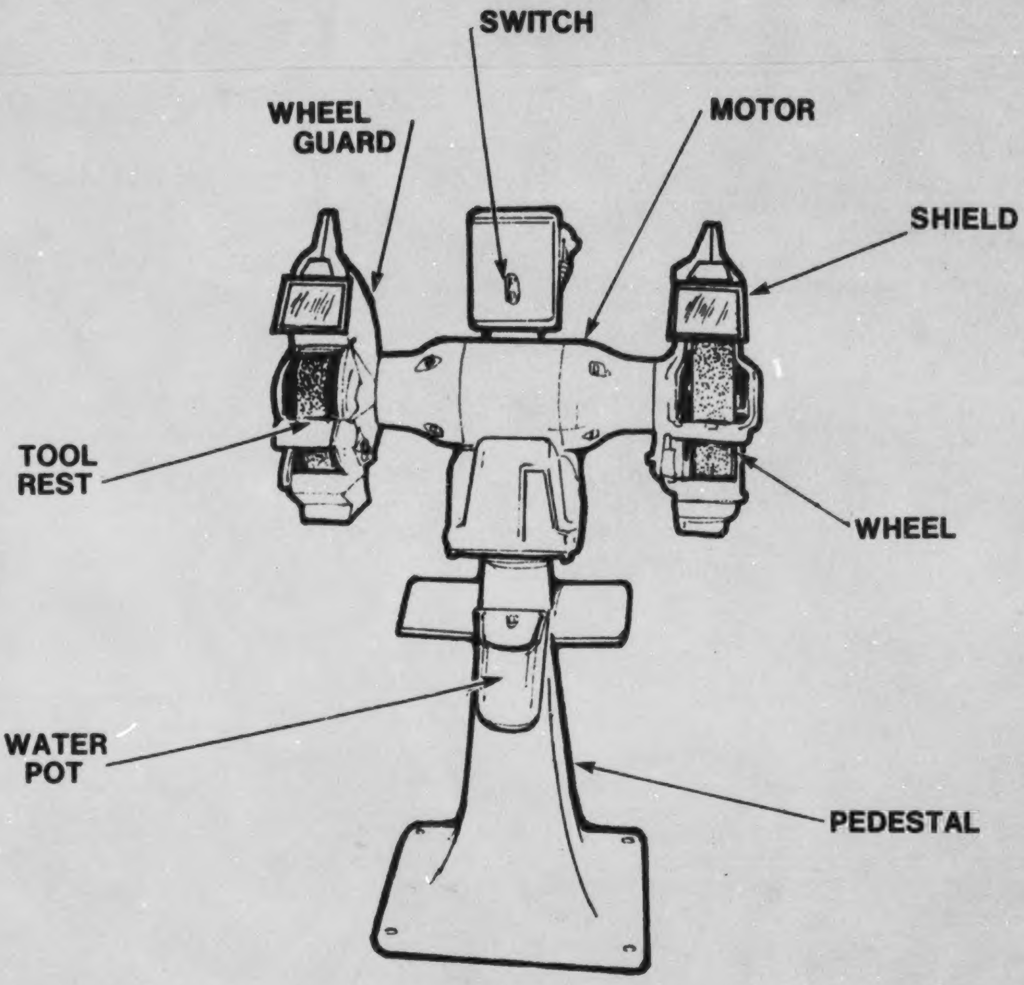


TOOLMAKER'S GRINDER



PORTABLE GRINDER

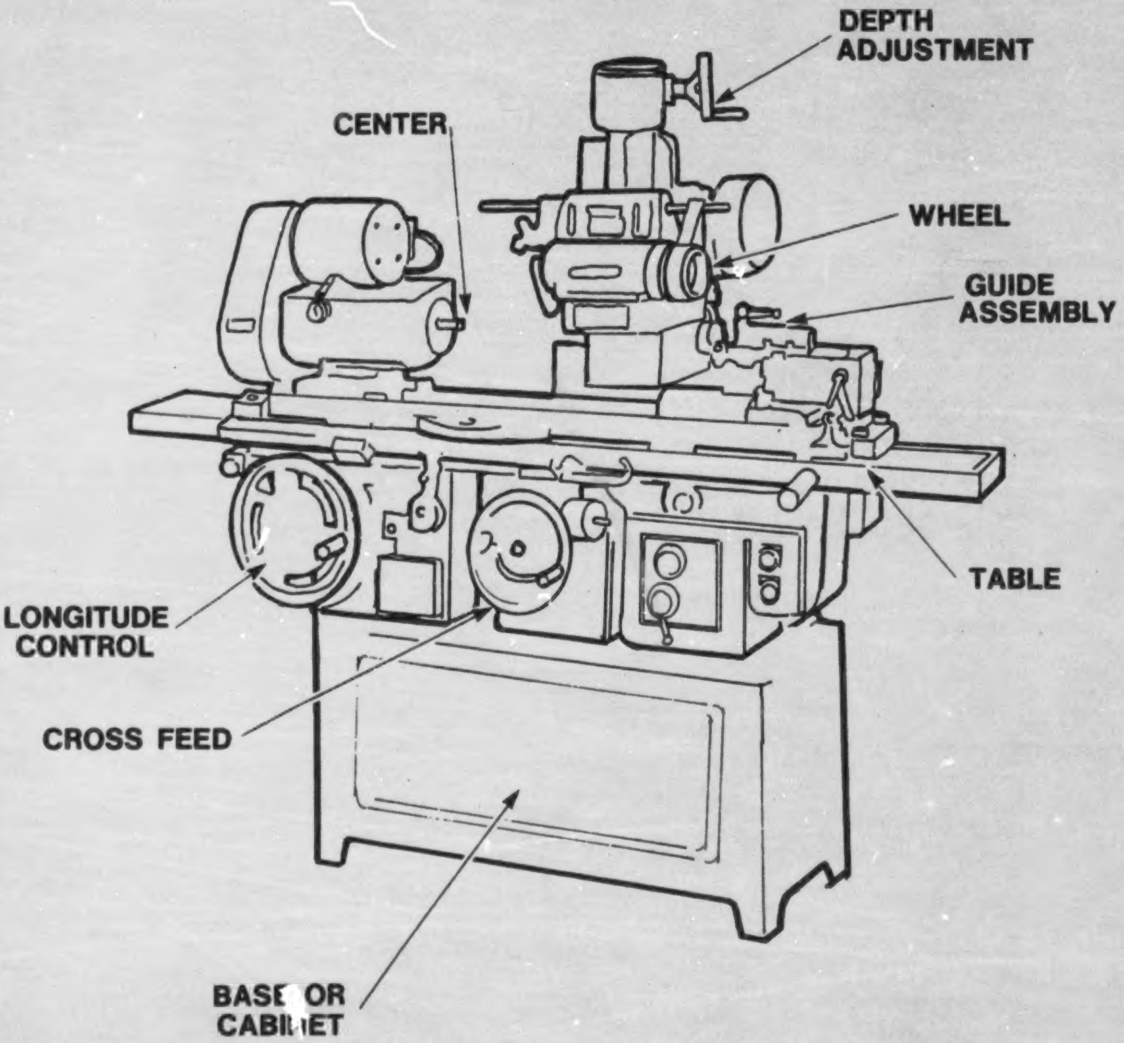
PARTS OF THE PEDESTAL GRINDER


SWITCH
WHEEL GUARD
MOTOR
SHIELD
TOOL REST
WHEEL
WATER POT
PEDESTAL

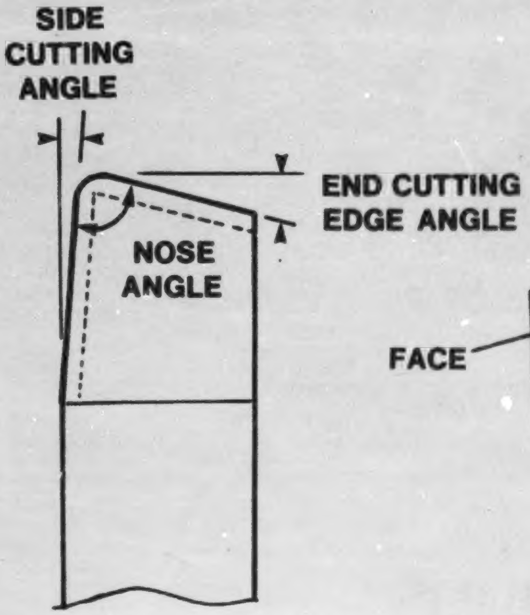
THE GRINDING WHEEL MARKING SYSTEM

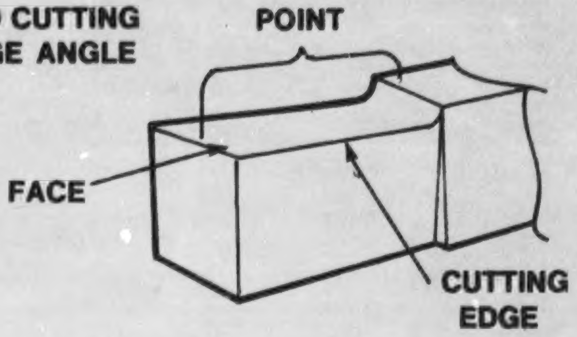
	(1)	(2)	(3)	(4)	(5)	(6)
(PREFIX)	KIND OF ADHESIVE	GRAIN SIZE	GRADE OR HARDNESS	STRUCTURE	BOND TYPE	MANUFACTURER'S RECORD
30	C	54	Z	15	S	BE
Manufacturer's Symbol Specifing Exact Kind of Abrasive	A Aluminum Oxide C Silicon Carbide	(Coarse) (Fine) 10 70 12 70 14 90 15 100 20 120 24 150 (Medium) 180 30 (Very 36 Fine) 46 220 54 240 60 280 320 400 500 600	Soft to Hard A Soft N B O C P D Q E R F S G T H U I V J W K X L Y M Z	Dense to Open 1 Dense 9 2 10 3 11 4 12 5 13 6 14 7 15 Open 8	V Vitrified S Silicate R Rubber B Resinoid E Shellac O Oxychloride	Manufacturer's Marking to Identify Wheel May be a Letter Or Number or Both To Indicate Variation of Bond or Wheel Characteristics.

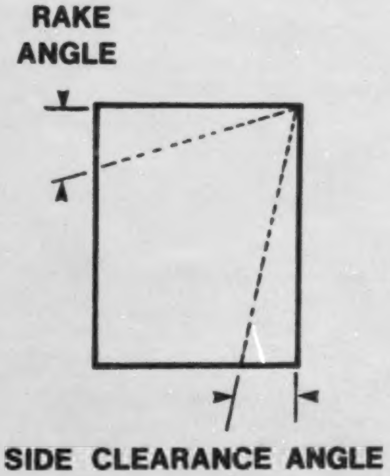
PARTS OF THE TOOLMAKER'S GRINDER

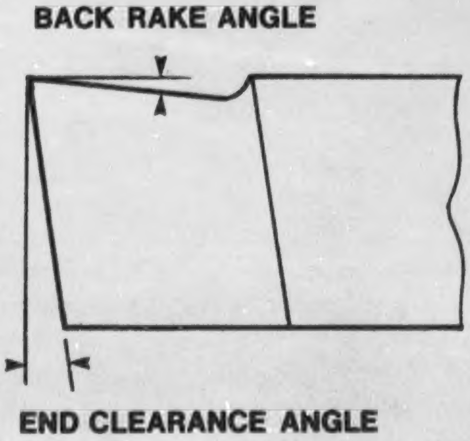

DEPTH ADJUSTMENT
CENTER
WHEEL
GUIDE ASSEMBLY
TABLE
LONGITUDE CONTROL
CROSS FEED
BASE OR CABINET

PARTS OF THE LATHE TOOL

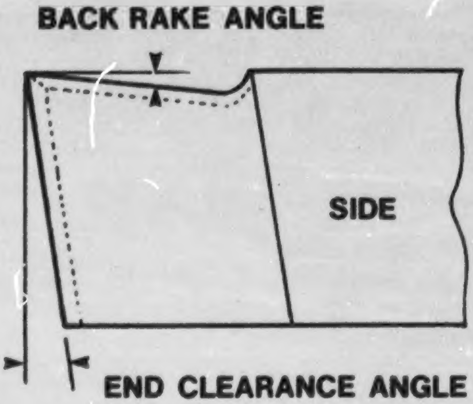

SIDE CUTTING ANGLE
END CUTTING EDGE ANGLE
NOSE ANGLE

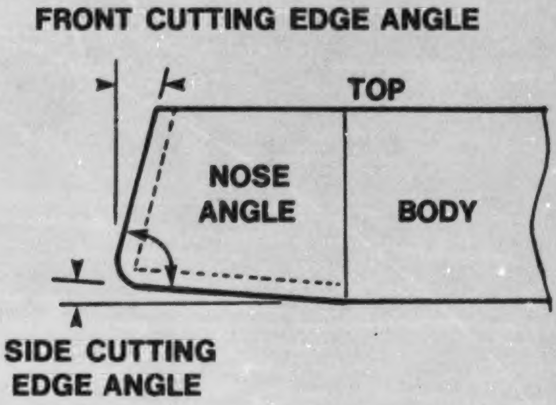

POINT
FACE
CUTTING EDGE

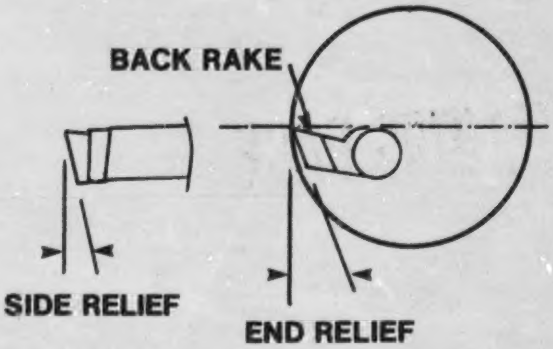

RAKE ANGLE
SIDE CLEARANCE ANGLE

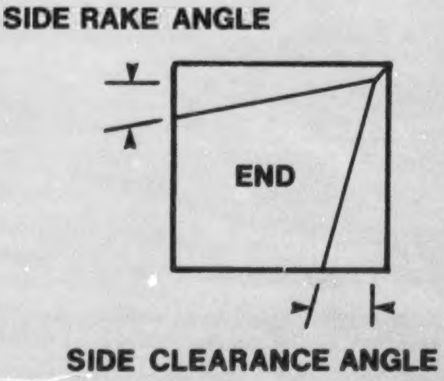

BACK RAKE ANGLE
END CLEARANCE ANGLE

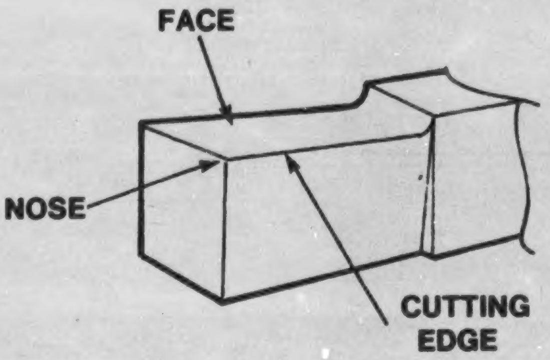
CUTTING TOOL ANGLES


BACK RAKE ANGLE
SIDE
END CLEARANCE ANGLE


FRONT CUTTING EDGE ANGLE
TOP
NOSE ANGLE
BODY
SIDE CUTTING EDGE ANGLE


BACK RAKE
SIDE RELIEF
END RELIEF


SIDE RAKE ANGLE
END
SIDE CLEARANCE ANGLE


FACE
NOSE
CUTTING EDGE

UNIT IV

GRINDING OPERATIONS

JOB SHEET 6--GRIND A THREADING TOOL FOR THE LATHE

I. Tools and materials

   A. Tool steel blank

   B. Pedestal grinder

   C. Water tray

   D. Safety glasses

   E. Bevel protractor

   F. Shop rag

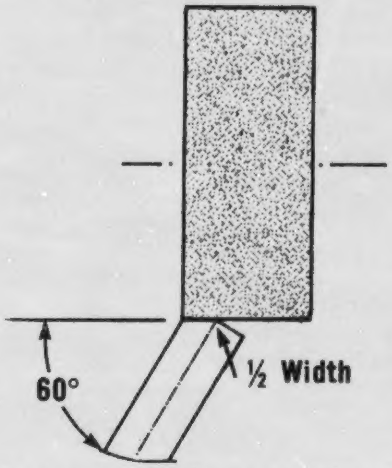
   G. Center gauge

II. Procedures

   A. Adjust the tool rest to within 1/8 clearance of the grinding wheel.

   B. Put on safety glasses.

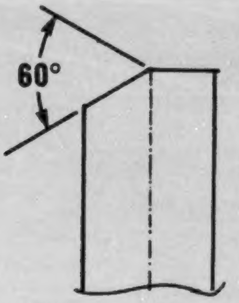
   C. Grind one side of the point of the threading tool at a 60-degree angle.



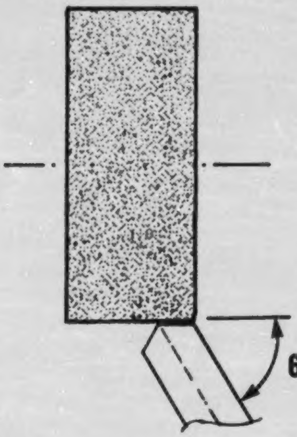
(NOTE: Grind about halfway across the tool.)

CAUTION: Cool the tool steel often.

D. Check the angle with a bevel protractor.

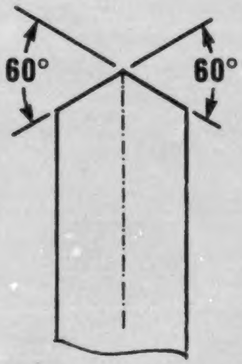


E. Grind the other side of the tool at a 60-degree angle.

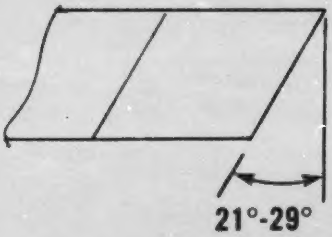


(NOTE: Grind the side until the blank forms a point.)

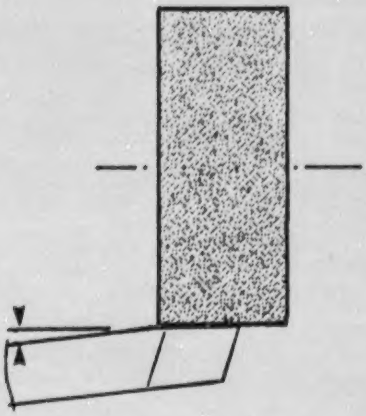
F. Check the angle with a bevel protractor.



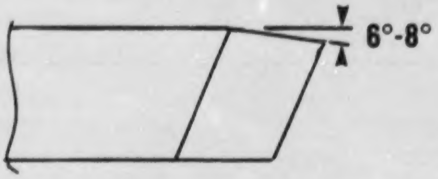
G. Check the front clearance angle.



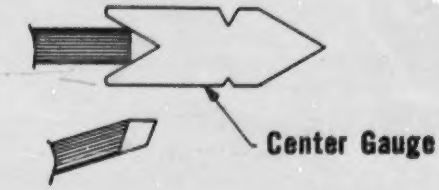
H. Grind the top rake angle at 6-8 degrees.



I. Check the rake angle with the bevel protractor.



J. Check the point of the tool with the center gauge.



K. Correct any angles that are not as specified.

L. Hone each flat surface on the oil stone.

M. Turn off the grinder.

N. Clean up the work area.

UNIT IV

GRINDING OPERATIONS

TEST PART 1

1. Explain the process of removing metal with a grinder.

2. Match terms associated with grinding operations to the correct definition by placing the number of each term on the right in the correct blank on the left.

_____a. A material used to remove or cut metal from a work piece by a rubbing or friction process.

_____b. A process of smoothing or aligning the grinding wheel.

_____c. The condition of a grinding wheel when the pores or surface of the wheel is full of metal particles and will not grind properly.

_____d. The term applied to a cutter which has a cutting edge made of hard carbide.

_____e. The process of removing roughness or small metal chips from the cutting edges of a cutting tool.

_____f. The condition of a grinding wheel when the surface of the wheel becomes slick and will not grind.

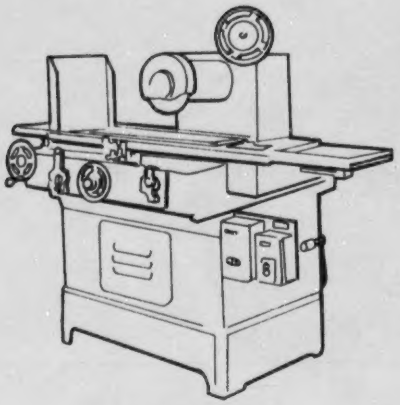
_____g. The area on a cutting tool that is shaped to provide a cutting edge.

_____h. The area on a cutting tool that is shaped so it will not rub on the work piece being cut.

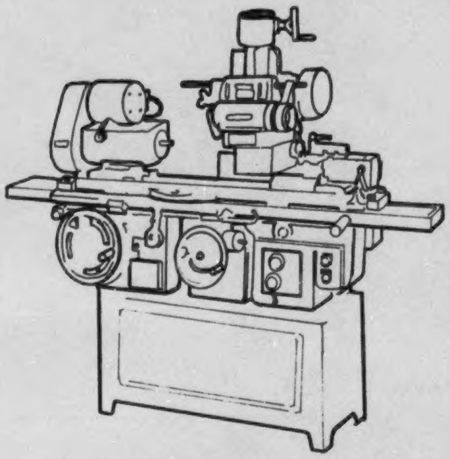
1. Glazed
2. Loaded
3. Honing
4. Carbide-tipped
5. Dressing the wheel
6. Rake
7. Clearance angle
8. Abrasive

3. Identify the types of grinding machines used in the machine shop by writing the name of each under the correct illustration. Choose from the list below.

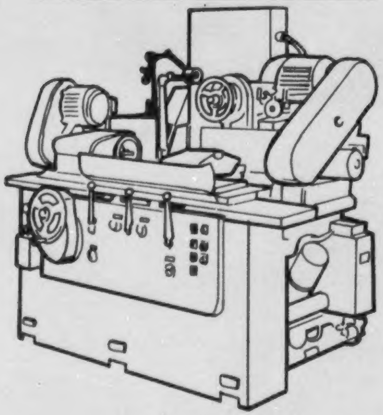
Portable
Utility
Surface
Centerless
Toolmakers



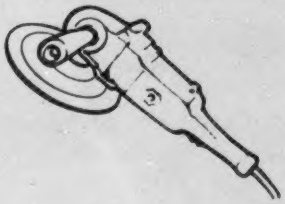
a. ____________________



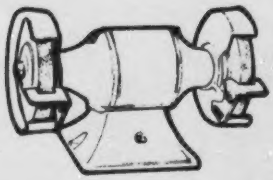
b. ____________________



c. ____________________



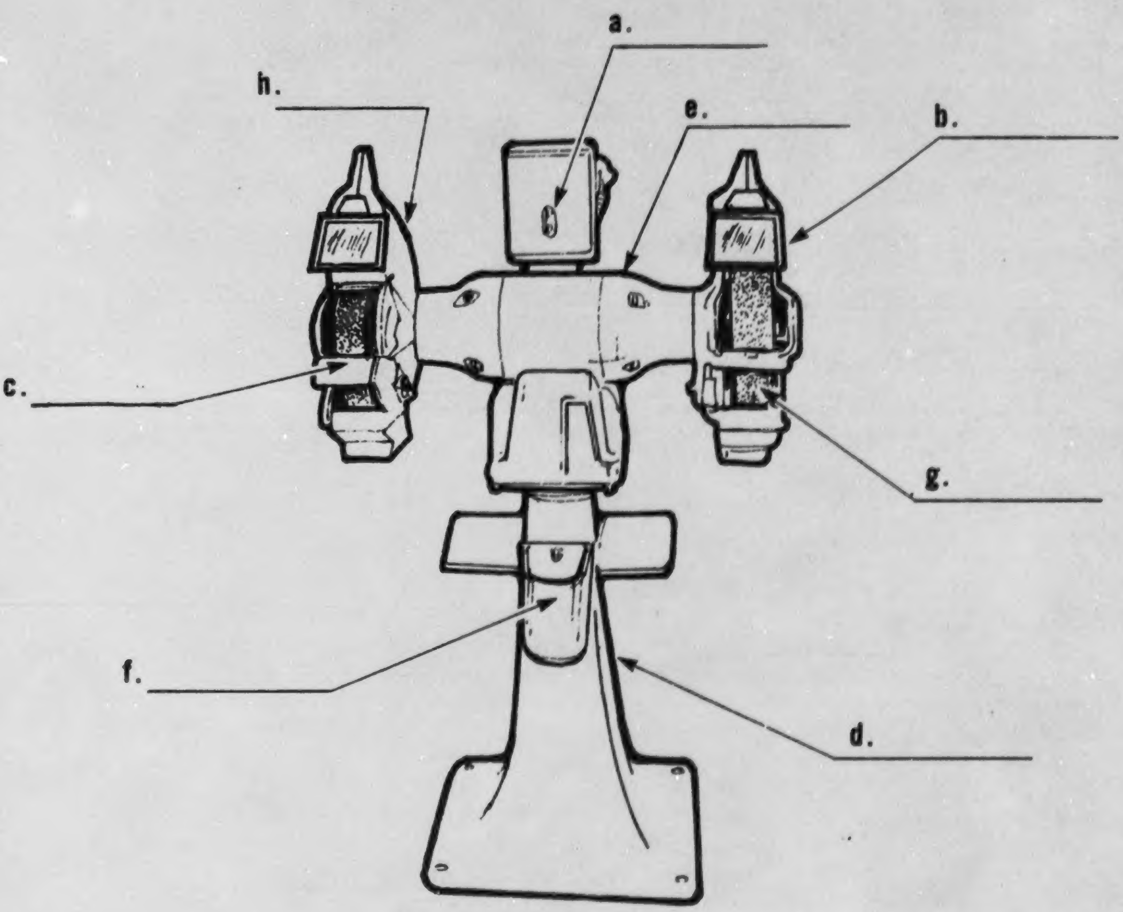
d. ____________________



e. ____________________

4. Point out the parts of the pedestal grinder by writing the name of each part listed below in the correct blank in the illustration.

Wheel
Wheelguard
Motor
Tool rest
Switch
Shield
Water pot
Pedestal



5. Select the correct safety practices to follow when operating grinders by answering each statement below as TRUE or FALSE.

_____a. The tool rest should be one inch away from the grinding wheel.

_____b. Grinding should be done on the face of the wheel only.

_____c. The wheel should be dressed every six months.

_____d. You should stand to one side of the wheel when you turn it on.

_____e. Stay in one spot on the wheel when grinding.

_____f. Begin grinding as soon as the grinder is turned ON.

_____g. Keep the tool as hot as possible.

_____h. Do not use a wheel that is cracked or that vibrates.

_____i. Keep your fingers away from the grinding wheel.

_____j. Do not grind soft metals, such as aluminum.

_____k. Make adjustments on the grinder when it has reached full RPM.

_____l. Use the wheel dresser only after receiving instructions.

_____m. Grinding wheels should always be sound-tested before they are installed.

_____n. Grinding wheels should not be operated at higher speeds than are recommended on the label.

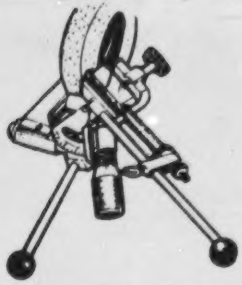
UNIT IV

GRINDING OPERATIONS

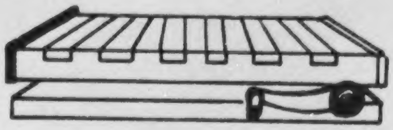
TEST--PART 2

1. Identify the accessories that are used in grinding operations by writing the correct name in the blanks. Choose from the list below.

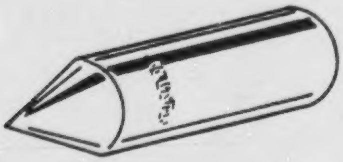
Mechanical hand dresser
Diamond dresser
Drill grinding attachment
Magnetic chuck
Grinding wheels



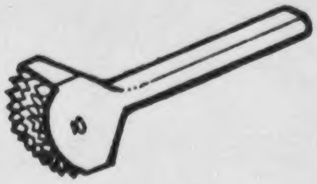
a. ______________________



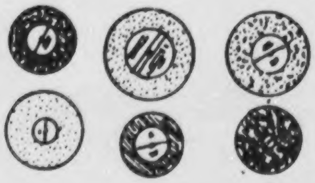
b. ______________________



c. ______________________



d. ______________________

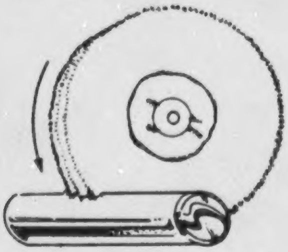


e. ______________________

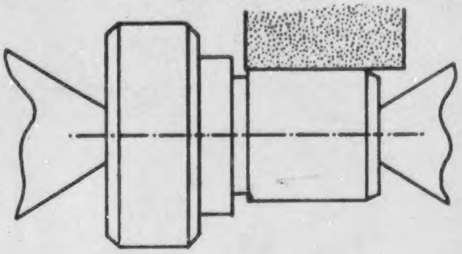
2. Point out the basic grinding operations of the various grinding machines used in a machine shop. Label each with the correct name, choosing from the list below.

Buffing
Off-hand grinding
Grinding plain mill cutters
Horizontal shaft grinding
Internal grinding

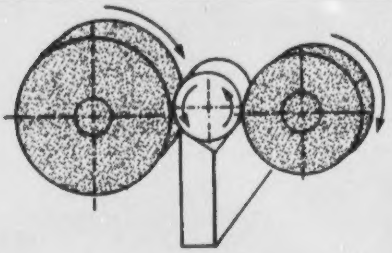
Form grinding
Plunge grinding
Grinding end-mill cutters
Vertical shaft grinding
Centerless grinding



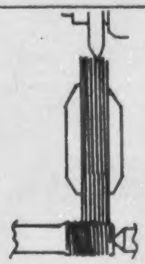
a. ______________________________



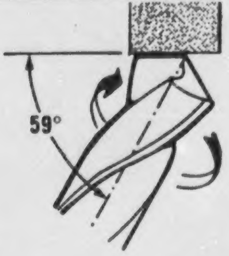
b. ______________________________



c. ______________________________



d. ______________________________



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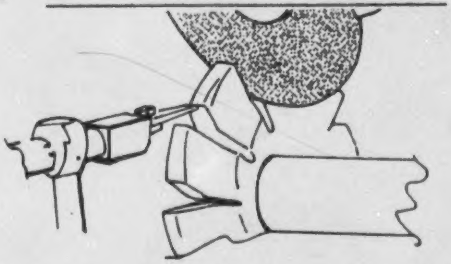

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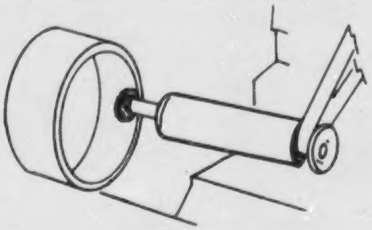

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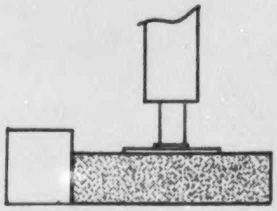

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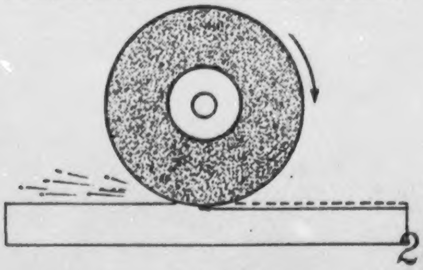
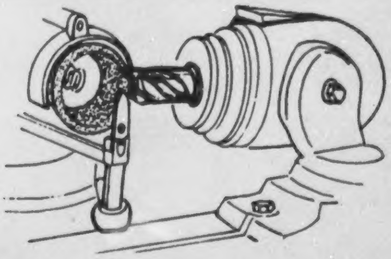


i. ______________________________



j. ______________________________

UNIT IV

GRINDING OPERATIONS

ANSWERS TO TEST

Part 1

1. Explanations should include:

    a. The grinder removes metal from the workpiece in small chips which are cut by the abrasive (rough) wheel with thousands of small cutting edges.

    b. Grinding can be done by hand or in combination with other machine tools on flat, round, or uneven surfaces.

2. a. 8
    b. 5
    c. 2
    d. 4
    e. 3
    f. 1
    g. 6
    h. 7

3. a. surface
    b. toolmaker's
    c. centerless
    d. portable
    e. utility

4. a. Switch
    b. Shield
    c. Toolrest
    d. Pedestal
    e. Motor
    f. Waterpot
    g. Wheel
    h. Wheelguard

5. a. False
    b. True
    c. False
    d. True
    e. False
    f. False
    g. False
    h. True
    i. True
    j. True
    k. False
    l. True
    m. True
    n. True

Part 2

1. a. Drill grinding attachments
    b. Magnetic chuck
    c. Diamond dresser
    d. Mechanical hand dresser
    e. Grinding wheels

2. a. Buffing
    b. Plunge grinding
    c. Centerless grinding
    d. Form grinding
    e. Off-hand grinding
    f. Grinding plain mill cutters
    g. Vertical shaft grinding
    h. Horizontal shaft grinding
    i. Internal grinding
    j. Grinding end mill cutters

UNIT V

SHAPER OPERATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to explain the operation of the shaper, identify the parts of the shaper, and point out the basic operations. The student will also be able to use the correct terminology and safety practices in performing the various shaper operations. This knowledge will be evidenced through demonstration and by satisfactorily completing the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student will be able to:

1. Explain the basic operation of the shaper.
2. Match terms associated with shaper operations.
3. Identify the parts of the shaper.
4. Select the correct safety practices to follow when operating a shaper.
5. Identify the accessories used with the shaper.
6. Identify the basic operations that may be performed on a shaper.
7. Demonstrate the ability to:
    a. Square a workpiece.
    b. Machine a keyway.

UNIT V

SHAPER OPERATIONS

SUGGESTED TEACHING ACTIVITIES

I. Objective sheet

  A. Discuss the unit objective with the students.

  B. Discuss each specific objective with the students.

  C. Have students complete the objectives in the most logical sequence for shop organization.

  D. Add any objectives necessary.

II. Information sheets

  A. INFORMATION SHEET 1--INTRODUCTION TO SHAPER OPERATIONS

    1. Explain the operation of the shaper.

    2. Identify the various parts of the shaper (Transparency 1).

    3. Discuss the safety practices related to operating the shaper.

  B. INFORMATION SHEET 2--SHAPER OPERATIONS AND ACCESSORIES

    1. Discuss the use of the various accessories for the shaper (Transparency 2).

    2. Discuss the various operations performed on the shaper.

III. Transparency masters

  A. TM-1--PARTS OF THE SHAPER

  B. TM-2--SHAPER CUTTING TOOLS

IV. Job sheets

  A. JOB SHEET 1--SQUARE A WORKPIECE

    1. Provide material for the students'work.

    2. Demonstrate the procedures for squaring the workpiece.

  B. JOB SHEET 2--MACHINE A KEYWAY

    1. Provide students with 1" diameter stock with a hole predrilled for the end of the keyway.

    2. Demonstrate the machining procedures.

V. Unit test

A. The unit test is divided into two parts.

(NOTE: Each part covers one information sheet.)

B. Various approaches may be used in testing:

1. Each part of the test may be given as the student reviews the information on each information sheet.

2. Give the entire test upon completion of all information sheets in the unit.

3. Give one or more of the parts of the test as an additional assignment, or to reinforce areas the student did not understand.

C. Add test parts corresponding to any information area or sheets added to the unit.

VI. Answers to the test

A. Answers are based on total information provided in the unit.

B. For convenience of grading, add corresponding answer sheets for additional test parts.

VII. References

A. A Suggested Basic Course Outline for General Metal Trades Cluster. Occupational Curriculum Laboratory, East Texas State University, Commerce, Texas 75428.

B. Walker, John R. Modern Metalworking. Goodheart-Wilcox Co., Inc. South Holland, Illinois. 1976.

UNIT V

INFORMATION SHEET 1--INTRODUCTION TO SHAPER OPERATIONS

I. Operation of the shaper

A. The shaper removes metal from the workpiece by means of a single-point cutting tool which moves back and forth across the workpiece.

B. The shaper machines flat surfaces in horizontal, flat, and angular positions.

C. Shapers are sized by the maximum length of material that the tool can machine in one stroke.

EXAMPLE: A 12-inch shaper has a maximum stroke of 12 inches.

II. Terms and definitions

A. Contour--the outline of an object

B. Pivot--A shaft on which something turns

C. Serration--A saw-toothed or notched shape on the surface

D. Stroke--The movement of the shaper ram in one direction.

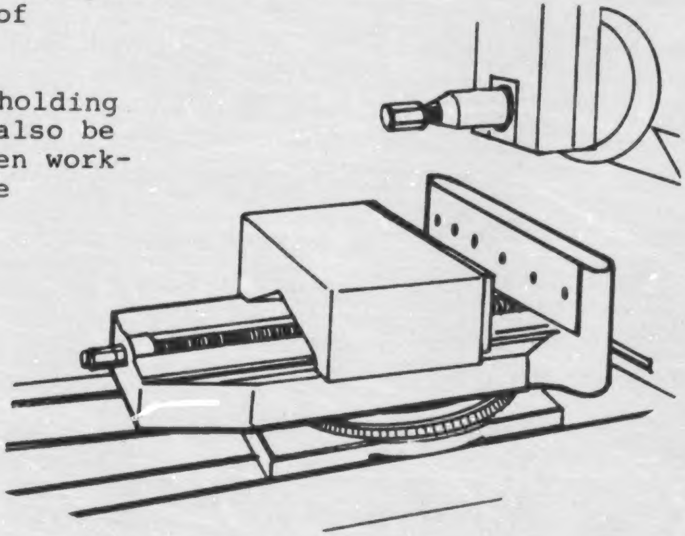
III. Parts of the shaper

A. Base and column--Support the other parts of the shaper and provide a reservoir for lubricants.

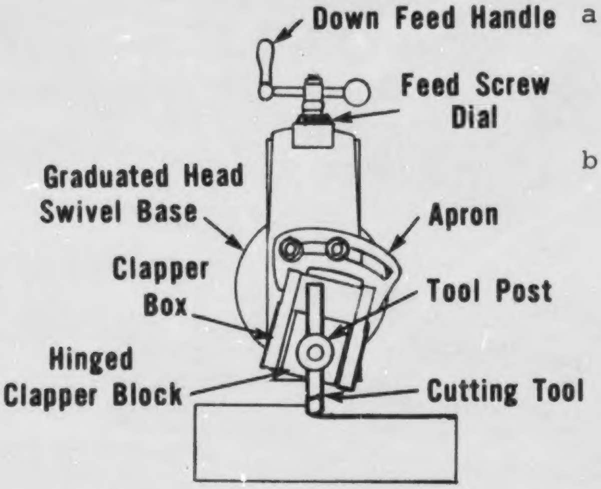
B. Ram--Provides the stroke for the cutting action of the machine.

C. Vise--Adjusts by swiveling the base and adjustment of the lead screw.

(NOTE: Special workholding devices can also be used to fasten workpieces to the table.)



D. Tool head--Mounts on the front of the ram to provide a means of holding and positioning the cutting tool.



a. Swivel mount--provides a means of rotating the cutting tool through a full 180° arc or more.

b. Lead screw--contains a micrometer collar that allows precision adjustments to be made by using a handwheel.

c. Apron--provides a means of turning the cutting tool at an angle to the tool slide, and contains:

(1) Clapper box--which allows the cutting tool to tilt up on the return stroke without damaging the cutting tool.

(2) Hinge pin--provides a pivot point for the clapper block.

(3) Clapper block--holds the tool post.

(4) Tool post--holds the cutting tool.

E. Motor assembly--Provides power for the shaper operations.

F. Table--Supports the vise.

G. Apron--Provides a surface for the movement of the table.

(NOTE: The apron can be hand or power-fed.

IV. Shaper safety practices

A. Wear goggles to protect eyes from flying chips.

B. Keep away from the front of the shaper tool.

(NOTE: When chips are thrown, they are hot and can cause burns.)

C. Keep hands and objects away from between the work and the tool.

D. Turn off the power when making adjustments.

E. Use a brush to remove chips and shavings with the machine OFF.

F. Keep the tool properly sharpened, and handle it properly.

G. Keep the workpiece securely fastened in the vise or to the table.

H. Make sure the ram and head will clear the workholding devices.

I. Check and set the correct cutting speed, feed, and depth of cut before starting.

J. NEVER lay any tools on the machine.

K. Always make sure the machine is at a complete stop before leaving the machine for any reason.

UNIT V

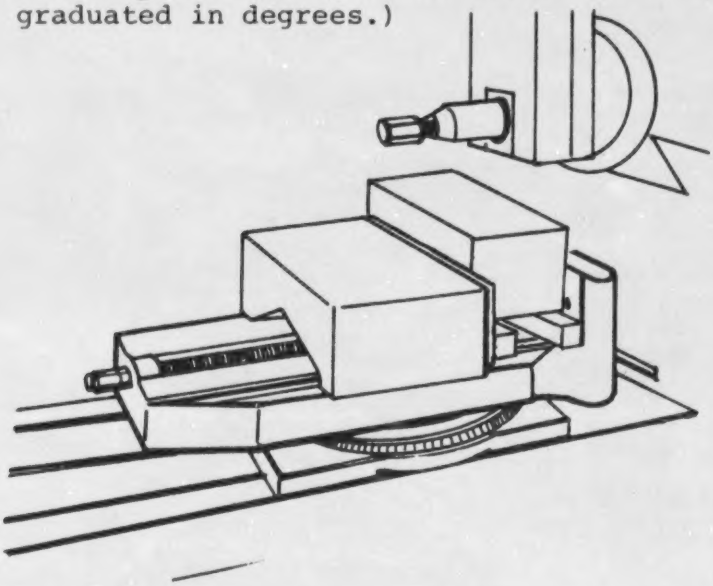
SHAPER OPERATIONS

INFORMATION SHEET 2--SHAPER ACCESSORIES AND OPERATIONS

I. Accessories

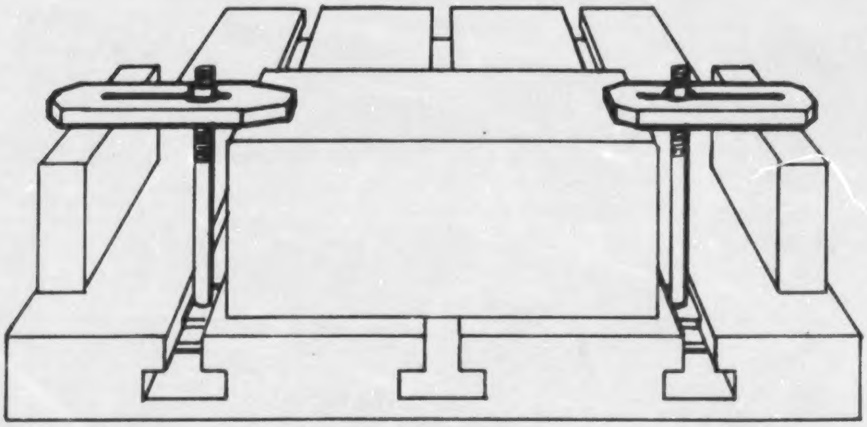
A. Swivel vise--Used to hold most workpieces on the table.

(NOTE: The body of the vise will swivel on a base which is graduated in degrees.)



B. Parallels--Used to level or raise the surface of the workpiece in the vise.

C. Holddowns--T-slot bolts and straps used to attach a workpiece directly to the table.



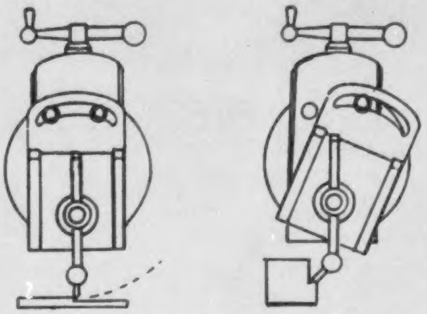
D. Cutting tools--These are ground into the shape required for the operation being performed. (See TM-2)

II. Operations

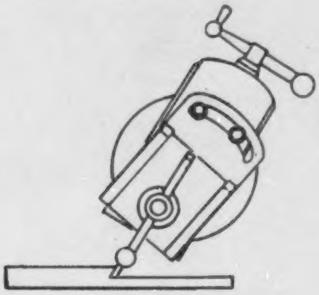
A. Surfacing

1. Horizontal

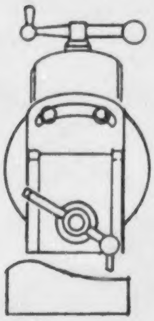
2. Vertical



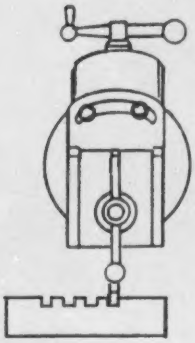
B. Angular cutting



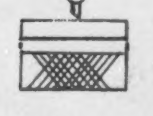
C. Contour or form cutting



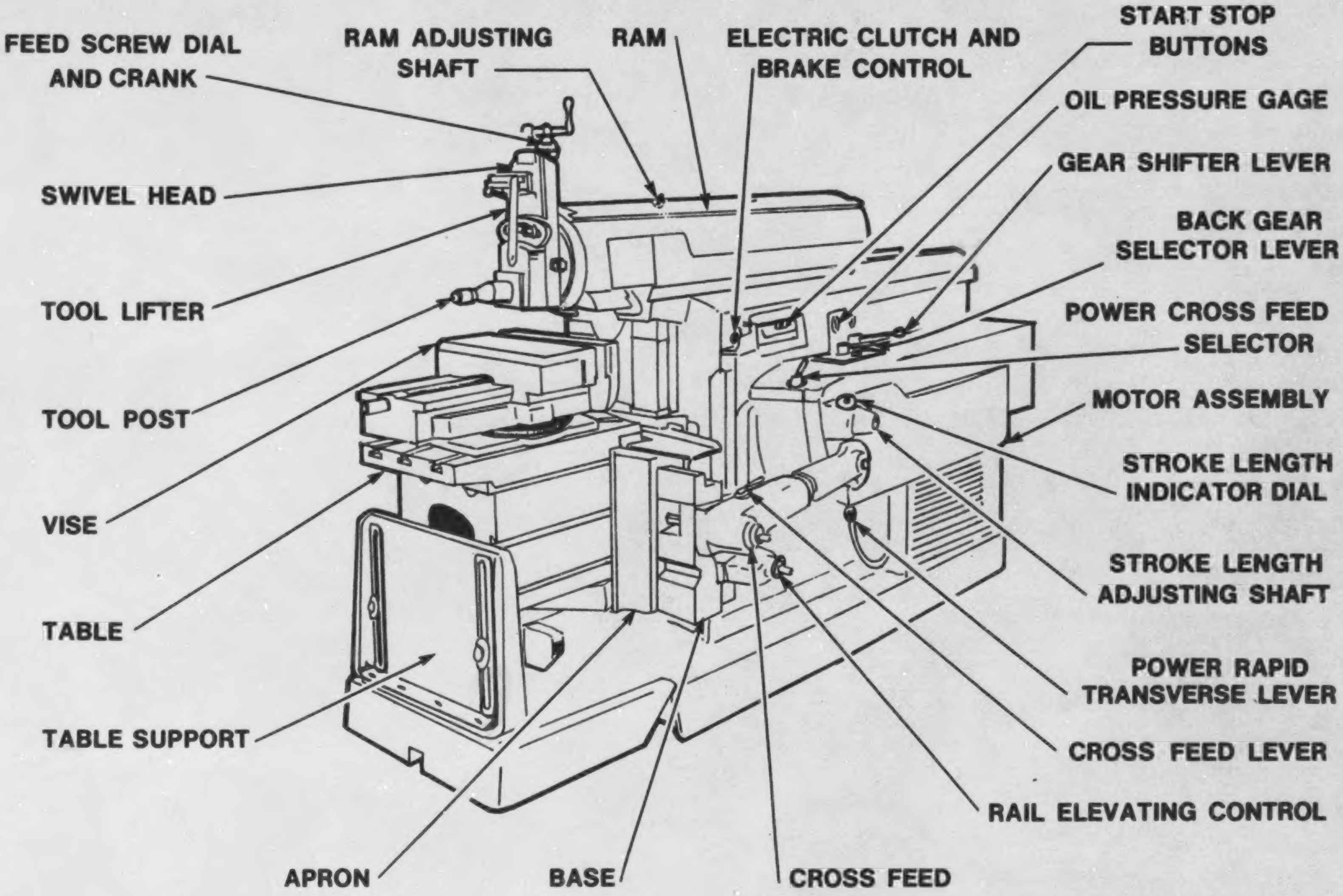
D. Keyway cutting or slotting



E. Serrations



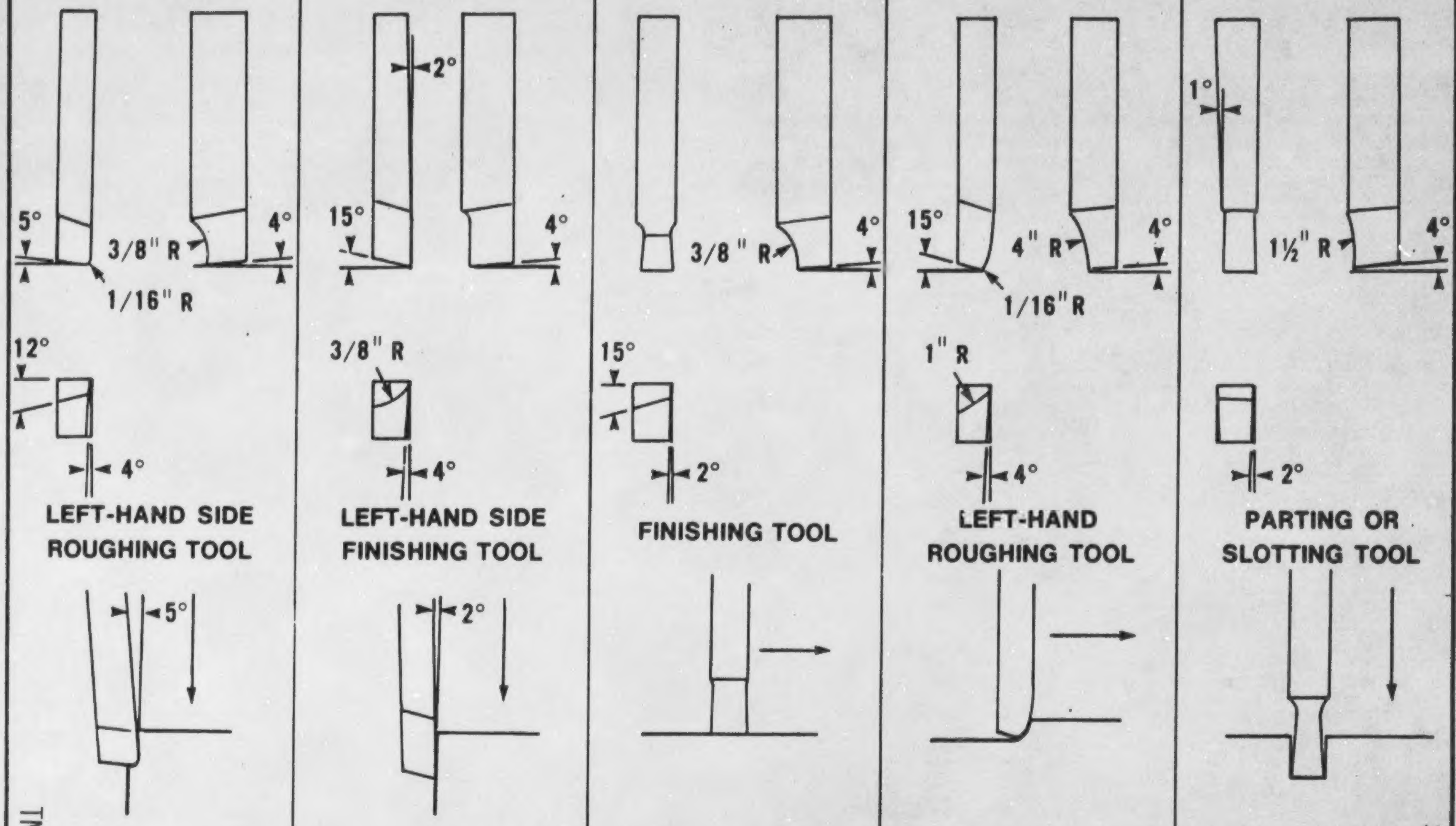
PARTS OF THE SHAPER


FEED SCREW DIAL AND CRANK
RAM ADJUSTING SHAFT
RAM
ELECTRIC CLUTCH AND BRAKE CONTROL
START STOP BUTTONS
OIL PRESSURE GAGE
GEAR SHIFTER LEVER
BACK GEAR SELECTOR LEVER
POWER CROSS FEED SELECTOR
MOTOR ASSEMBLY
STROKE LENGTH INDICATOR DIAL
STROKE LENGTH ADJUSTING SHAFT
POWER RAPID TRANSVERSE LEVER
CROSS FEED LEVER
RAIL ELEVATING CONTROL
SWIVEL HEAD
TOOL LIFTER
TOOL POST
VISE
TABLE
TABLE SUPPORT
APRON
BASE
CROSS FEED

TM-1

325

SHAPER CUTTING TOOLS


5°
3/8" R
4°
1/16" R
12°
4°
5°
2°
15°
4°
3/8" R
4°
2°
3/8 " R
4°
15°
2°
15°
4" R
4°
1/16" R
1" R
4°
1°
1½" R
4°
2°

LEFT-HAND SIDE ROUGHING TOOL

LEFT-HAND SIDE FINISHING TOOL

FINISHING TOOL

LEFT-HAND ROUGHING TOOL

PARTING OR SLOTTING TOOL

UNIT V

SHAPER OPERATIONS

JOB SHEET 1--SQUARE A WORKPIECE

I. Tools and and materials

A. Shaper tool

B. Parallels

C. Metal bar (½ inch diameter)

D. Shop rag

E. Brush

F. Mill file

G. Workpiece (4" x 3" x 6")

H. Trysquare

II. Procedures

A. Put on your safety glasses

B. Remove any burrs or chips from the workpiece

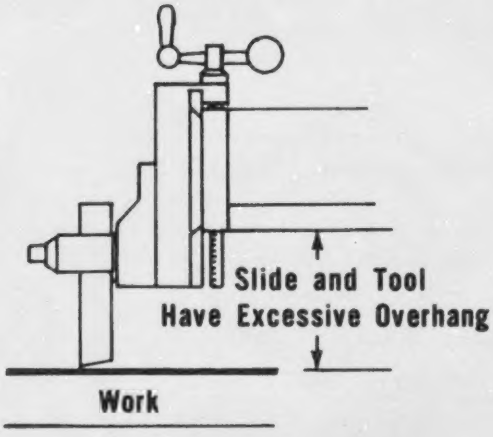
C. Clean the jaws and bottom of the vise

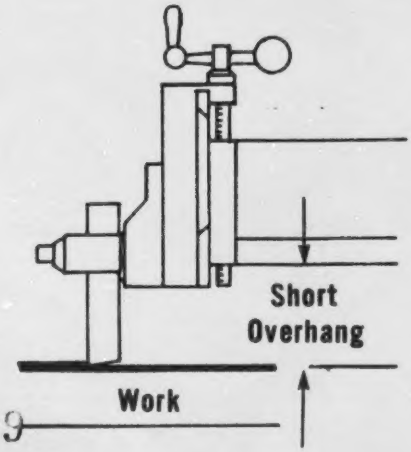
D. Place the workpiece on the parallel bars in the center of the vise.

E. Securely tighten the vise on the workpiece.

F. Place the roughing tool in the tool holder.

CAUTION: The tool should not extend from the tool holder any further than necessary.


Slide and Tool
Have Excessive Overhang
Work


Short
Overhang
Work

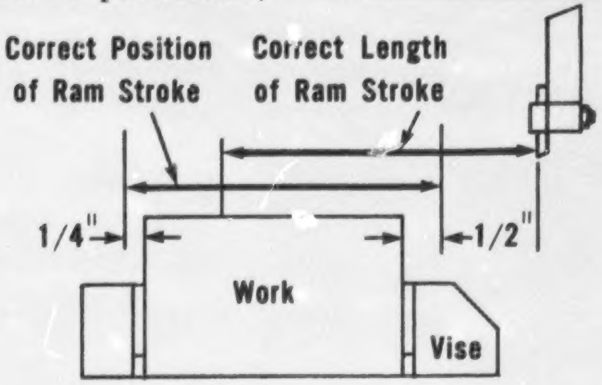
G. Adjust the table until the tool is even with the top of the workpiece.

H. Set the correct cutting speed.

(NOTE: Speed is the number of strokes per minute.)

I. Adjust the length of stroke.

(NOTE: The length of stroke is the total of the width of the workpiece, plus 1/4" to 3/4" at the end of the stroke to allow the clapper box to drop back into normal position.)



J. Position the ram correctly over the workpiece.

K. Set the feed.

(NOTE: The feed is the distance the work travels after each cutting stroke.)

L. Set correct depth of cut.

(NOTE: The harder the metal is, the lighter the depth of cut should be.)

M. Turn the machine over by hand before turning on the power.

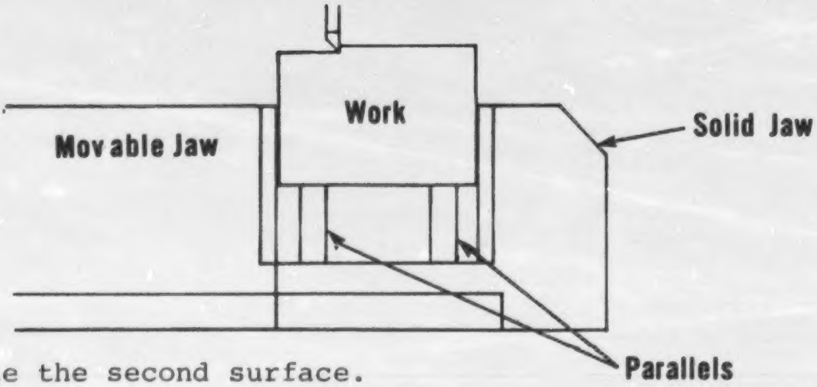
(NOTE: This will allow you to make sure the ram will not hit the work.)

N. Start the machine and make first pass cut.

O. Stop the machine, check the workpiece, and make necessary adjustments.

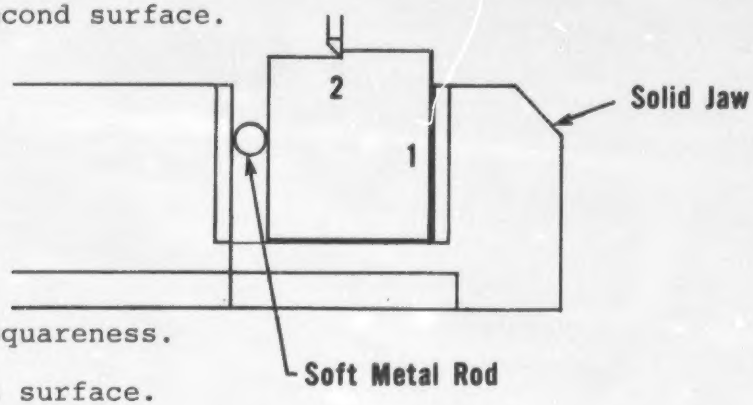
P. Complete the facing operation on side one.

(NOTE: Use a finishing tool if a smooth finish is specified.)


Work
Movable Jaw
Solid Jaw
Parallels

Q. Machine the second surface.

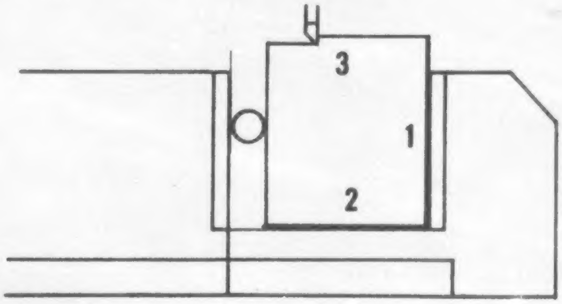
1. Place the workpiece in the vise so the faced surface is against the solid jaw of the vise.
2. Place a soft metal rod between the workpiece and the adjustable jaw.
3. Tighten the workpiece securely.
4. Face the second surface.


2
1
Solid Jaw
Soft Metal Rod

5. Check for squareness.

R. Machine a third surface.

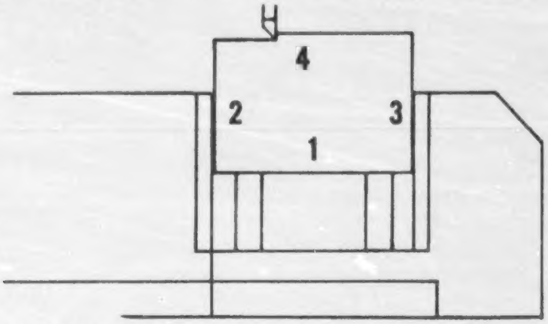
1. Place the workpiece in the vise so that the surface 2 is on the bottom of the vise and surface 1 is against the solid jaw of the vise.
2. Place the soft metal rod between the workpiece and the adjustable jaw.
3. Tighten the workpiece securely.
4. Face the third surface to the correct width.



5. Check for squareness.

S. Machine the fourth surface.

1. Place the workpiece in the vise so that side one is resting on parallels.
2. Tighten the workpiece securely.
3. Face the fourth surface to the correct width.



4. Check for squareness.

T. Machine the two ends to the correct length.

U. Remove the burrs from the workpiece with the file.

V. Clean up the work area and turn in tools.

W. Turn in the workpiece to your instructor.

UNIT V

SHAPER OPERATIONS

JOB SHEET 2--MACHINE A KEYWAY

I. Tools and materials

  A. Parting or slotting shaper tool

  B. Parallels

  C. Shop rag

  D. Brush

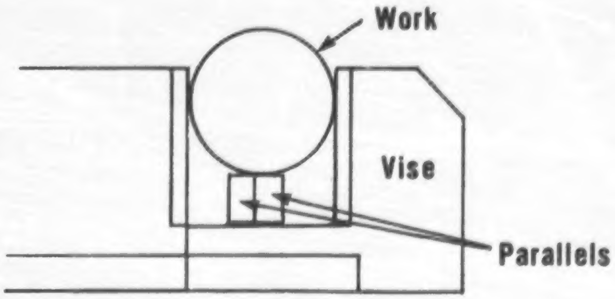
  E. Mill file

  F. Workpiece (1" diameter stock with the correct diameter hole predrilled at the end of the keyway location.)

II. Procedures

  A. Put on safety glasses

  B. Place the workpiece in the vise so that it can be machined easily.



  C. Securely tighten the vise on the workpiece.

  D. Place the shaper tool in the tool holder.

  CAUTION: The tool should not extend from the holder any further than necessary.

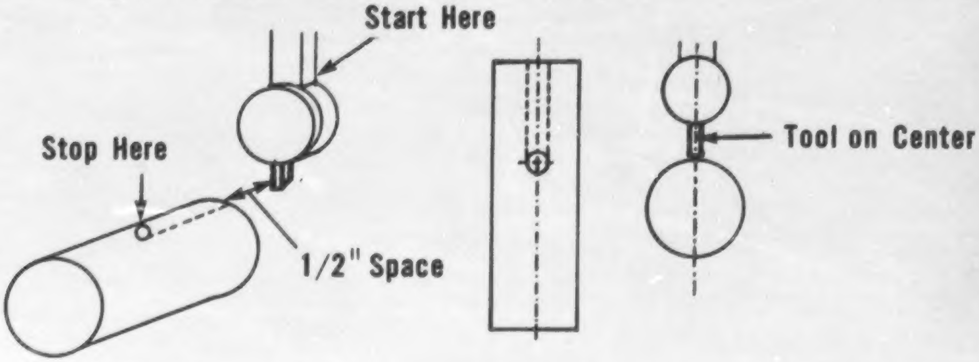
E. Adjust the table so the tool is even with the top of the workpiece.

F. Set the correct cutting speed.

(NOTE: Speed is the number of strokes per minute.)

G. Adjust the length of stroke.

(NOTE: The stroke should stop at edge of the drilled hole and should provide ½" at the start of the stroke to allow the clapper box to drop back into normal position.)



H. Position the ram correctly over the workpiece.

I. Lock the table so the feed does not move the table.

J. Set the correct depth of cut.

(NOTE: The tool can be fed into the round workpiece by hand or with the vertical power feed.)

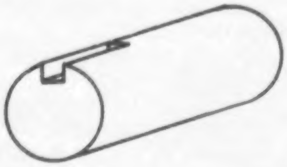
K. Turn the machine over by hand before turning on the power.

(NOTE: This will allow you to make sure the ram will not hit the work.)

L. Start the machine and make a light cut.

M. Stop the machine and make necessary adjustments.

N. Complete the cutting operation to the correct depth.



O. Remove burrs from the workpiece with a file.

P. Clean up the work area and turn in tools.

Q. Turn in the workpiece to your instructor.

UNIT V

SHAPER OPERATIONS

TEST PART 1

1. Explain the basic operation of the shaper.

2. Match the terms associated with shaper operations to the correct definition by placing the number of each term on the right in the correct blank on the left.

____a. A shaft on which something turns

____b. The outline of an object

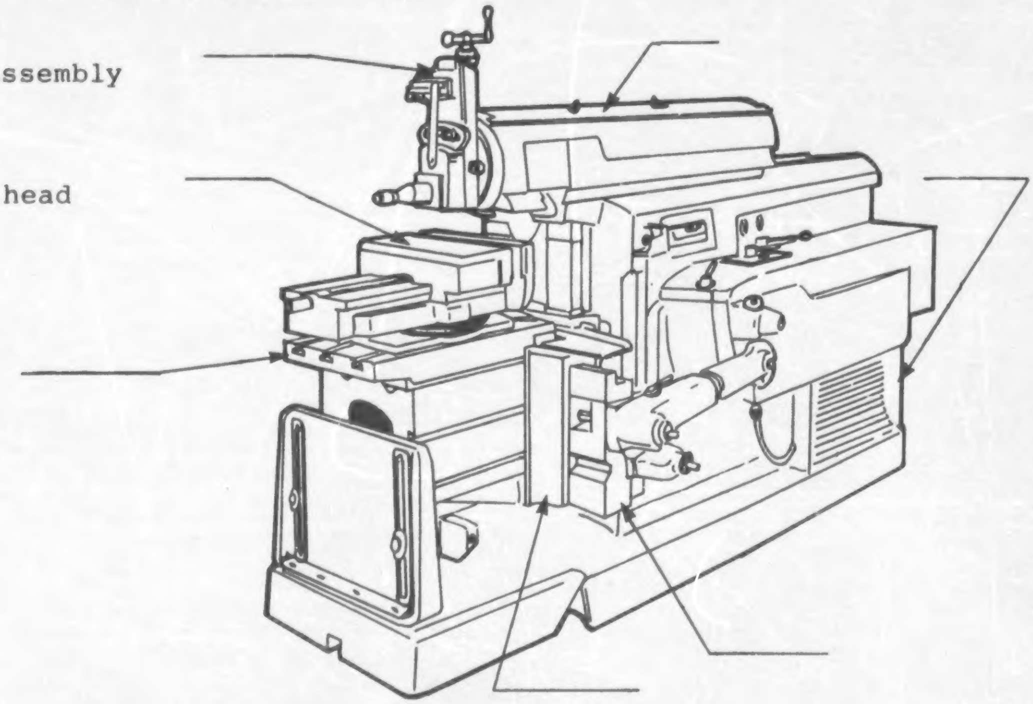
____c. The movement of the shaper ram in one direction

____d. A saw-toothed or notched shaped surface

1. Serrations
2. Stroke
3. Pivot
4. Contour

3. Identify the parts of the shaper by writing the name of each listed below in the correct blank.

Base
Motor Assembly
Apron
Vise
Ram
Swivel head
Table



4. Select the correct safety practices to follow when operating a shaper by answering each statement below "True" or "False."

_____a. Lay tools on the machine in a safe place.

_____b. Have the machine running at low speeds when making adjustments.

_____c. Make sure the ram and head will clear the work holding devices.

_____d. Use the same cutting speeds and feeds settings for different workpieces.

_____e. Keep from in front of the shaper tool.

_____f. Wear safety goggles to protect your eyes from flying chips

_____g. Use a shop rag to remove chips and shavings from the machine.

_____h. Keep the tool properly sharpened.

_____i. Keep the workpiece securely fastened in the vise or to the worktable.

_____j. Keep hands from between the work and tool.

UNIT V

SHAPER OPERATIONS

TEST PART 2

1. Identify the accessories used with the shaper by writing the name of each listed below in the correct blank.

Swivel vise	Holddowns
Parallels	Cutting tools

a. T-slot bolts and straps used to attach a workpiece to the table are called ______________________.

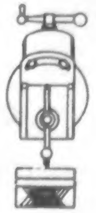
b. ______________________ are often used to level a workpiece in the vise.

c. The most common method of holding a workpiece on the table is a ______________________, which may be switched on the base.

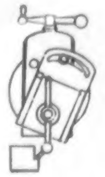
d. The ______________ __________ can be ground into the shape required for the operation being performed.

2. Identify the accessories used with the shaper by writing each of the names listed below in the correct blank.

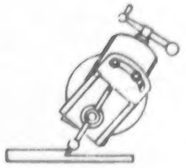
Contour cutting	Surfacing
Angular cutting	Keyway cutting
Serrations	



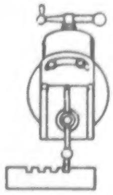
a. ______________________



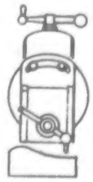
b. ______________________



c. ______________



d. ______________



e. ______________

UNIT V

SHAPER OPERATIONS

ANSWERS TO TEST

Part 1

1. Answer should include:
    a. The shaper removes metal from the workpiece by means of a single pointed cutting tool which moves back and forth across the workpiece.

    b. The shaper machines flat surfaces in horizontal, flat, and angular positions.

    c. Shapers are sized by the maximum length of material the tool can machine in one stroke.

2. a. 3
    b. 4
    c. 2
    d. 1

3. a. Ram
    b. Swivel head
    c. Vise
    d. Table
    e. Apron
    f. Base
    g. Motor assembly

4. a. F
    b. F
    c. T
    d. F
    e. T
    f. T
    g. F
    h. T
    i. T
    j. T

Part 2

1. a. Holddowns
    b. Parallels
    c. Vise
    d. Cutting tools

2. a. Serrations
    b. Surfacing
    c. Angular cutting
    d. Keyway cutting
    e. Contour cutting